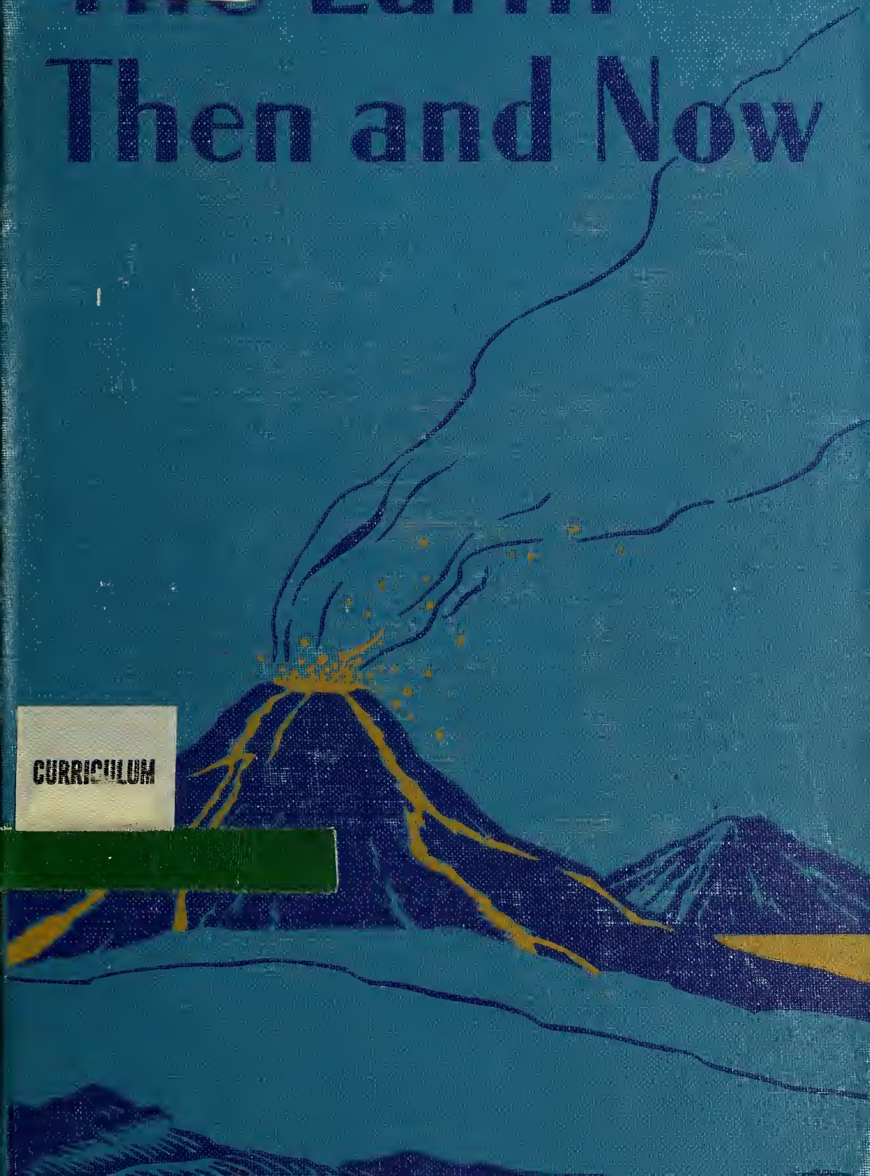
ARCHIVES

The Earth Then and Now



CURRICULUM

Ex libris
Universitatis
Albertaensis

UNIVERSITY OF ALBERTA
QUAECUMQUE VERA

SUMMER SCHOOL FOR TEACHERS

EL. e:

Digitized by the Internet Archive
in 2016 with funding from
University of Alberta Libraries

https://archive.org/details/newpathwaysinsci06crai

NEW · PATHWAYS · IN · SCIENCE

The Earth Then and Now

By

GERALD S. CRAIG, *Consultant in Elementary Science Horace Mann School, and Associate Professor of Natural Sciences, Teachers College, Columbia University*

GOLDIE M. JOHNSON, *Formerly Supervisor of Elementary Science, Montclair, New Jersey*

and

JUNE E. LEWIS, *Assistant in Science Department Plattsburg State Normal School, Plattsburg, New York*

GINN AND COMPANY

BOSTON · NEW YORK · CHICAGO · LONDON · ATLANTA

DALLAS · COLUMBUS · SAN FRANCISCO

COPYRIGHT, 1940, BY GINN AND COMPANY
COPYRIGHT, 1940, IN THE PHILIPPINE ISLANDS
ALL RIGHTS RESERVED

840.7

New Pathways in Science

▪

We Want to Know
CRAIG · BURKE · BABCOCK

▪

We Find Out
CRAIG · BURKE

▪

Changes All Around Us
CRAIG · BALDWIN

▪

Our Earth and Sky
CRAIG · BALDWIN

▪

The Earth and Life Upon It
CRAIG · HURLEY

▪

From Sun to Earth
CRAIG · CONDRY · HILL

▪

The Earth Then and Now
CRAIG · JOHNSON · LEWIS

LIBRARY OF THE UNIVERSITY
OF ALBERTA

SUMMER SCHOOL FOR TEACHERS

163
.C3EN
bk.6

Contents

121570

YOU have read many times about the lives of great men and women. You have learned where and when they were born, what they did when they were children, and something about the adventures they had when they grew up.

The earth too has a story. There was a time when there was no earth. When it was born, it may have been about the same size as it is now. Perhaps it was smaller. As the earth became older, it had many adventures and changed a great deal. Great rivers and oceans were formed on its surface, and great wrinkles, called mountains, were pushed up. It shook with earthquakes. It spouted forth streams of melted rock.

Perhaps the greatest event was the coming of life, and especially of man. No story of the earth is complete without an account of man. Man alone of all the living things of the earth is interested in studying about things on the earth and in the sky and in finding their secrets.

This book will tell you about the earth and its story. The story of your favorite hero began with his birth and ended with his death. Perhaps he lived to be sixty, seventy, or a hundred years old. But the story of the earth covers millions of years. Millions of creatures have lived and died, races of men have come and gone, even mountain ranges have been made and worn down to level plains. The story of these things is the story of the earth.

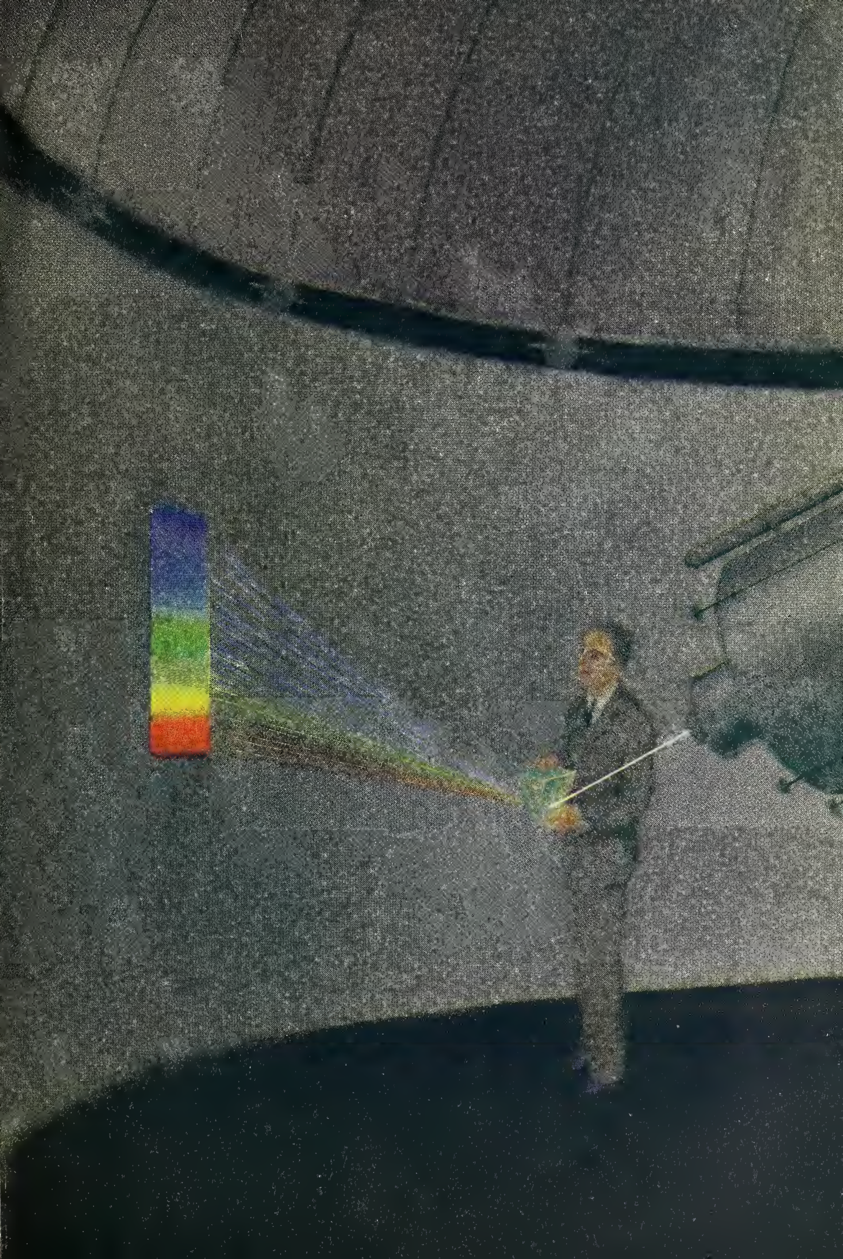
The Earth Then and Now

I

Man Has Learned about the Universe

THE STUDY OF STARS BEGAN LONG AGO

WHAT IS BEYOND OUR SOLAR SYSTEM?



HAVE you ever watched the stars on a clear night? Have you ever thought that boys and girls watched those same stars hundreds and even thousands of years ago?

Do you think they understood about those tiny lights in the sky? They probably did not, because no one at that time knew much about the stars. But there came a time when ancient people began to study and to learn about the stars, even though at first they had no instruments to help them. They slowly learned many things. By watching the stars they learned to know when the seasons would change. They learned when to plant and when to harvest their crops. People used the sun to tell the time of day and the stars to guide them as they traveled at night.

Since the stars could help them in many ways, there came a time when some men began to believe that stars could do other things for them. These men thought that they could foretell their futures by the stars. They thought they could foretell wars and the rise and fall of nations. Many strange and untrue stories grew up about the stars.

Then, later, some men began to think differently. They watched and studied the stars. They experimented, or worked, to discover the truth about the stars, as the man is doing in the illustration facing page 8. He is showing that light from the sun and stars may be broken up into different colors. The invention of the telescope and other instruments helped men further in their studies. Slowly they began to change the old ideas. From that time on they have learned and taught us more and more about the stars.

THE PICTURE FACING PAGE 8 IS FROM A PAINTING BY CHARLES BITTINGER.

The Study of Stars Began Long Ago

WHY THE ANCIENT PEOPLE THOUGHT AS THEY DID ABOUT THE STARS

The very first men, who lived thousands of years ago, knew very little about the earth upon which they lived. They knew much less about the sun, moon, and stars. They were busy hunting food and protecting themselves from wild animals and the weather.

No one knows when men first began to think about the stars. No one knows when ancient men looked up at the sky and for the first time became interested in the things they saw there. Whenever it was, it must have been long before the history of the human race began to be written.

We can only guess how human beings began, little by little, to learn about the sky. Perhaps they first noticed that the sun, moon, and stars seemed to move across the sky; or they began to see that the sun "came up" in the east each morning. They may have watched it as it seemed to travel across the sky during the day. Perhaps they noticed that the day was warmer when the sun was overhead. In the evening they saw the sun disappear from sight. Daylight faded as the blue of the sky changed to crimson, purple, and gold. Then as darkness closed in about them, men watched the stars "come out" slowly, one by one. They watched and wondered.

What were these tiny lights that flickered in the sky? What was the moon that it could not shine brighter than the sun? What made either of them shine? Why did the stars fade away and not shine in the daytime? Early men must have thought about these things and many more.

These early shepherds were able to learn
a few things about the stars by watching them

As centuries passed, some men learned to raise sheep and to become shepherds. Perhaps, as they watched their flocks night after night, they noticed that the stars seemed to reach a certain position just before dawn. In this way they may have learned to know when their long night of watching would soon be over, and thus to tell time by the stars.

Some men, little by little, learned to farm. As they did so, they began to use the sky to help them. They learned to watch the movement of the sun to know when it was time to plant their crops. When the days became longer, it was the sign that the time of showers and warm weather was coming. When the days became shorter, it was time to think of the harvest and to prepare for winter.

But even though men learned to watch the way the sun and other stars seemed to move, they still did not know what those objects were. They did not know what caused the positions of the stars to change. These were only a few of the many things they wished to know about.

Now if there is something you wish to know, you may ask someone who knows a great deal about it, or you may try to find the answer in some book. But men and women, or boys and girls, could not do that in those early days. They probably asked questions, but nobody could answer the questions because no one knew any more than they. Men had not studied the stars for centuries before them. The people of those early times had not learned to think things out for themselves. There were no scientists to tell them about things. Nor were there books for them to read. Therefore they could not learn much about the heavenly bodies.

Neither could anyone go to museums or science laboratories where men work to learn about things. There were none of these places. Telescopes and other instruments had not been invented. There was no way and no place where men could learn about the things they wished to know.

As century after century passed and men were not able to learn the true answers to their questions, some of them made up their answers. They noticed that sometimes things happened which were good for men. At other times, harm-

ful things, such as severe storms, lightning, and fire, occurred. They began to think that there were good spirits which brought the good things and evil spirits which brought the harmful things.

The ancient Greeks and Romans believed that their gods and goddesses ruled the heavens, the sea, and the earth. When these people could not explain the sun, moon, and stars, and their movements, they made up stories to tell how their gods and goddesses caused the sun and other stars to move.

The ancient Greeks had a myth, or story, that showed what they thought about the sun. It said that the sun was a chariot of fire drawn by very swift horses. The god Apollo drove this chariot of fire through the sky each day from east to west. When Apollo drove the horses too close to the earth, there were very hot days. Sometimes he did not come very near. Then the days were cold.

Many Greeks thought that the earth was held up by a very strong man named Atlas. Atlas, they said, had displeased the gods, and for his punishment he had to stand in the ocean and hold the earth upon his shoulders.

The more that people imagined, the more they thought that the sun, moon, and stars, and the gods and goddesses, affected or changed their lives. They said that thunder and times when food was scarce were caused by angry gods. They thought they could bring rain in times of dry weather by doing something to please the gods. Other men thought that they could succeed in doing a task only when the stars were in certain positions. These are only a few of the queer beliefs of ancient people; there were many, many others.

Children grew up among some of these strange ideas, which we call superstitions. They heard their parents talk

about the terrible things the gods and stars caused. They saw their parents tremble in fear. Soon they became afraid. They were afraid that they would anger some god and cause him to harm them. During all their lives they were influenced or changed by these superstitions.

Many people became so influenced by these old ideas that they were afraid to change their beliefs when new ideas were brought to them. They were too filled with fear of what might happen to them. So, many of them continued to live and believe very much as their parents and grandparents had lived and believed for centuries.

During all the ages from the earliest times men have handed down superstitions as truth. And even now after we have learned much truth about the heavenly bodies, some people still believe that the sun, moon, and stars have a strange influence upon their lives.

Have you ever heard people wish when they saw a "falling star" or say "Money, money"? Some people do this just in fun because they have heard of the old belief. But other people really think that their wishes will come true if they wish when they see a "star" fall.

Often people are afraid of unusual things which happen in the sky and which they cannot explain. As recently as 1833 many people were frightened when there was a great shower of meteors, or "falling stars." Many thought that the world was coming to an end. They were afraid because they did not know what meteors were.

Meteor showers have frightened many people

Aristarchus had only simple instruments with which to study the stars

MAN HAS CHANGED HIS IDEAS ABOUT MANY THINGS

For hundreds and hundreds of years people kept and told their old beliefs. Their lives were filled with fear, trying to please angry gods or to keep them from becoming angry.

But about four thousand years ago, although most people believed in the old ideas, there were a few who were not satisfied with them. These few could not believe the stories they had heard. They began to search for the facts. These men

must have been very brave and intelligent, since they were willing to give up the old beliefs if they could find explanations which seemed better.

Of course, we do not know how these men started to doubt the old beliefs and superstitions. Perhaps they noticed that the sun appeared in the same part of the sky each morning. Maybe they wondered why the angry gods did not take the sun away. They may have watched the moon and noticed that it always changed in shape a little each night. They may have noticed that the seasons changed regularly. Summer always followed spring, and winter always followed autumn. After they had watched the movements of the sun, moon, and stars, these persons probably decided that everything moved regularly and did not depend on the wishes of supposed gods and goddesses.

It was not easy for these men to break away from the old ideas. They worked long and hard. Time after time they

This boy is using two lenses to look at a distant object.

This shows how a simple telescope works

were discouraged. People laughed at them. But they worked on and on. They continued to watch and study the movements of the stars. They tried to find out exactly how those bodies moved. They timed the movements. They had to watch and talk and think just as scientists do today.

Aristarchus, who lived over 2000 years ago, was one of these early astronomers. He had only very simple instruments with which to work. He taught that the earth was not the center of the universe, as most people believed, but that the planets, including the earth, traveled around the sun. However, only a very few people believed him.

These early scientists were greatly hindered in their work. They could think out ideas, but they had no way of proving them. Centuries passed, and then a Dutch spectacle-maker made an important discovery. He learned that by holding one of his lenses in front of another one he could make faraway things look closer. An instrument was made from this idea and was called a spyglass. In 1609, Galileo, who taught about the stars, heard of this instrument that would magnify things which were far away; that is, it would make them appear larger. He thought this might help scientists to prove their ideas about the stars. He immediately set to work to make such an instrument, known to us as a telescope.

When Galileo looked at the sky through his telescope, he saw many more stars than he had ever seen before. His telescope magnified only three times. Galileo wanted to see more. He wanted larger telescopes, and he set to work to make them.

Galileo did not see everything the first night, nor the second. He worked day after day upon new telescopes. Night after night he looked at the sky. He made several telescopes, each larger than the one before. He worked for

What did Galileo learn from studying the moon,
planets, and stars, through his telescope?

several years, during which time he made his most famous telescope that magnified things thirty-two times.

As Galileo studied the stars through his telescopes, he found that the Milky Way was no longer a mystery. It was not a river, as the Chinese had thought. Nor was it dust kicked up by a buffalo and a horse as they raced across the

sky, as the Indians had said. But it was made of millions and millions of stars.

Galileo noticed also that the moon did not shine of itself, but that it shone by light which it received from the sun; or, as we say, that it shone by reflected light. He saw that the moon had mountains upon its surface and that the planet Jupiter had moons traveling about it. He also discovered many other things that people had wondered about.

During the three hundred years since Galileo first gazed through his telescopes, many improvements have been made in such instruments. They are much larger and better now than they were at first; and by using them men have been able to learn many things about the universe. After men have had time to use the newer telescopes many new things will be discovered.

It is about four thousand years since a few men first began to give up their old beliefs and to search for the truth about stars. During all that time some men have continued to think and learn and to teach others. They have experimented or worked in science laboratories and in the out-of-doors. They have made instruments to help them in their study. Often they have made mistakes and have had to correct them. But they have continued to work, and they have learned many things about the sun, moon, and stars. Many are still searching for more truths about the entire universe.

THINGS TO THINK ABOUT

1. For thousands of years boys and girls have seen the same sun, moon, and stars that you see. During these thousands of years the sun, moon, and stars have changed very little; but man's ideas concerning them have changed a great deal.

2. Since early men did not know about the stars, many of them believed in superstitions. Some of the following statements are superstitions that some people still believe. Others are true statements. Can you tell which are true and which are only superstitions?

a. Friday the thirteenth is an unlucky day.

b. The moon revolves or travels about the earth.

c. Your future is influenced by the stars.

d. If you wish when you see a "falling star," your wish will come true.

e. Men do not know everything about the stars.

f. Some people are born under a lucky star.

g. Looking at the moon over the right shoulder brings good luck.

3. If you were alone on an island and were out of touch with the rest of the world, and if you had lost count of the days, could you tell

a. When spring or autumn was starting?

b. When to begin to store food for winter?

c. When it was noon and time to eat your lunch?

Very ancient people could do these things.

4. Scientists have learned so much about the stars that they can direct a telescope to a point in the sky where a star will be at any certain time in the distant future. If they could return at that time, they could look at the star without moving the telescope. Or a scientist might place the telescope so that another scientist centuries later could look at that star.

THINGS TO DO

1. Perhaps you can find someone who has a telescope. Ask him how much he has been able to learn by watching and thinking about the stars.

2. If the sun shines into your room, mark a line at the edge of some place where the sunshine strikes it. Note the hour and the day you made the line. Watch it each day. At the end of each week make another mark at exactly the same time of day. Do this for a month. The movement of the earth around the sun causes this change.

3. Some night when you are out camping, keep the alarm clock set so you will awaken every two hours. Notice the change in position of the stars during the night. Could you learn to tell when dawn was approaching? This change is caused by the rotation of the earth on its axis.

4. Look at the picture of Galileo's telescope and compare it with pictures of modern telescopes. How do they compare in size? in their power to magnify? How much more may be learned by using modern telescopes?

What Is beyond Our Solar System?

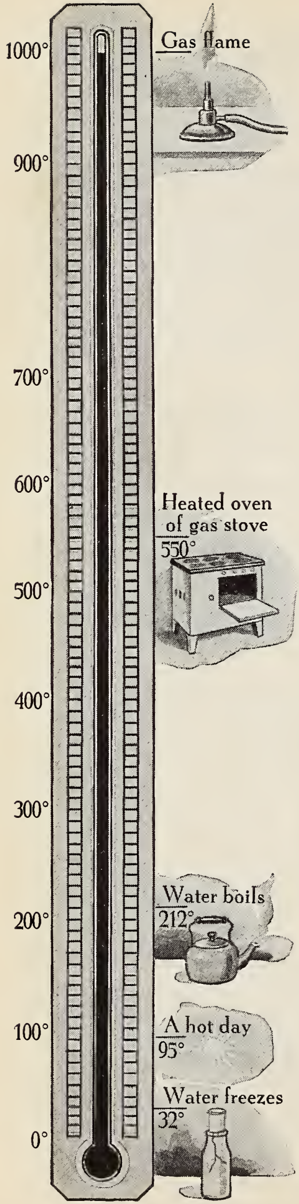
THE STARS

You know that the stars which shine in the sky are huge balls of very hot material. Some scientists think that they are so hot that nothing solid can be found in them. If anything solid could be thrown into the stars, scientists think that it would immediately burst into gases. These shining stars are all very much like our sun. They are all great masses of gases that are very, very hot.

Perhaps you know some temperatures which may help you to understand how very hot the stars are. In the summer when it is 95° F. or 100° F. in the shade, you think it is very hot. At the seashore it is sometimes 125° F. on the sand, and the sand burns your feet. Boiling water has a temperature of 212° F., and nobody wants to put his hands into boiling water. But none of these temperatures are near the temperatures of the stars.

There are higher temperatures that you know about. If you have something that controls the heat in the oven of your gas stove at home, you know that you can turn it to point to 550. That means that when it is heated, the temperature of the oven can become 550° F. A gas flame in some stoves may have a temperature of about 1000° F.; but that is not very hot if you compare it with the temperatures of some of the stars.

Should you like to know how hot some of the stars are? Scientists tell us that the temperature at the surface of the coolest stars which we see shining in the sky may be from 2500° F. to about 4000° F. That is, if you could make a thermometer which would not break or melt, and if you



could place it on the surface of these stars, it would show a temperature between 2500° F. and 4000° F. Now 4000° F. is about four times as hot as the hottest gas flame in your stove. Most of the stars are much hotter. They are more like the sun, whose surface temperature is about 11,000° F. The very hottest of the stars have surface temperatures which may be from 100,000° F. to 125,000° F. They are from a hundred to a hundred and twenty-five times as hot as the hottest flame in your gas stove.

We know how hot some of the stars are because men have measured their temperatures. Of course, you know that men cannot use a thermometer in measuring the temperature of a star; but they can use another instrument, which they call a thermocouple. Scientists focus a telescope on a star whose heat they want to measure. The light waves from the star pass through the telescope and fall upon a tiny spot on the thermocouple. This instrument

It would take a thermometer eleven times as long as this one to show the temperature at the surface of the sun

is made in such a way that the heat produced by the light waves starts a flow of electricity. Scientists measure this electricity and from it find the heat of the star.

The thermocouple measures the heat only of the surface of the stars. As yet men have no way of actually measuring the heat at the center of the stars. Perhaps someday an instrument will be made that will show those temperatures. Scientists think that the centers of many stars are many times hotter than their surfaces, maybe as hot as several million degrees.

Stars not only give off heat but they also give off light. Perhaps you have seen men heat a piece of iron so hot that it glowed red. As iron is heated more and more, it becomes so hot that it looks white and gives off a white light. Stars too are so hot that they give off light. We say they shine.

Heat and light are all the time being given off by the stars and are being sent out into space in all directions. A small part of this heat and light reaches the earth, a small part reaches other planets and other stars; but a very great part never reaches any object. The greatest amount goes out into space.

Have you ever wondered why some stars in the sky shine red; why others shine blue or white? Some scientists tell us that the color of stars is due to the amount of their heat. Those stars which have a red color have the lowest temperature. Their temperature probably is from about 2500° F. to about 4000° F. Some stars have a higher temperature than the red ones. They give off a yellow light. Still other stars are so hot that they are white. The very hottest stars are the bluish-white stars.

It may at first seem strange to you that men can learn what kinds of substances or things are in the stars. To do

this they use an instrument called a spectroscope. As the light from a star shines through the spectroscope, scientists can tell if the star contains oxygen, hydrogen, iron, copper, or other substances. With this instrument they have learned that the sun contains at least two thirds of the different kinds of things that are found in the earth. Someday they may know if the sun and other stars contain more of these substances.

If the stars were nearer to us, they would shine much brighter and appear much larger than they do. If they were as near to us as the sun, many of them would appear larger and brighter than the sun. But the stars are not near. They are millions of millions of miles away from us.

Men have found how far it is to many of the stars. They have invented instruments and found ways of using mathematics or figures to measure these great distances in the universe. To do this they need to use telescopes and to make very careful measurements.

Scientists use a very long "measuring stick" to tell us how far away the stars are. To understand about this measuring stick you will need to know more about the speed of light. There is nothing known that travels more rapidly than light. It travels at a little more than 186,000 miles a second. That means that light travels almost as far as seven and one half times around the earth in one second.

To realize how fast that is, compare it with the speed of an airplane, which is our fastest way of traveling. Suppose that an airplane travels three hundred miles an hour, and that it makes no stops. It would take such an airplane almost one month to travel as far as light travels in one second. You can see that at this rate light would travel millions and millions of miles in one year. The great distance that light

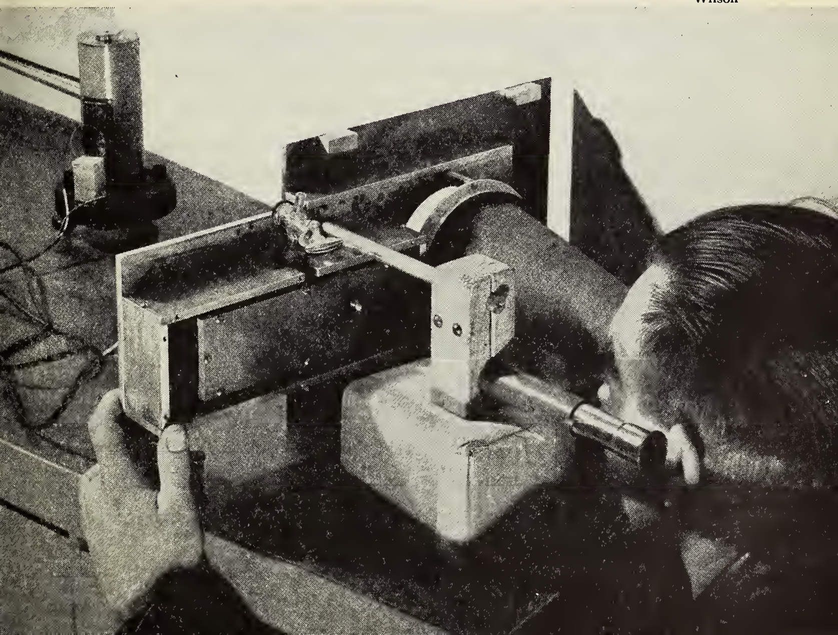
travels in one year is called a light year. Scientists use the light year to tell how far it is to stars and groups of stars in the sky.

As light comes from the sun to the earth, it travels about 93,000,000 miles. At the rate of 186,000 miles a second, it takes sunlight about eight minutes to reach the earth. That is only a very small part of a light year.

It takes light a little over four years to come to us from the next nearest star. Four years is a long time when compared with the eight minutes that it takes light to come to us from our nearest star, the sun. But it is not very long when compared with the time it takes light to come to us from some other stars.

By using this thermocouple, the man is able to measure the temperature at the surface of a star

Wilson



The light that we see coming from a few of the stars left those stars about the time that Columbus discovered America. The light from other stars started thousands of years ago, possibly when the cave men lived on the earth. Many stars are so far away that it takes their light millions and millions of years to reach the earth.

You have already learned that some stars are many times larger than others. Scientists prove this when they measure the stars. They find that the sun is a million times larger than the earth. If you could put a thousand times a thousand earths together, they would equal the size of the sun. And yet the sun is only an average or medium star in size.

Many, many stars are larger than the sun. Betelgeuse, in the constellation, or group of stars, known as Orion, is a star that is 27 million times as large as our star, the sun. That is, if you should put 27 times a thousand times a thousand of our suns together, you would have a star the size of Betelgeuse. But even Betelgeuse is not the largest star that has been measured. Antares, the largest star of those that have been measured, is more than 90 million times the size of the sun.

Perhaps at some time or other you have dropped something and then wondered why it fell down instead of up. Have you also wondered why it was that when you threw a ball into the air it came back down instead of going on and on? Scientists tell us that things fall to the earth because the earth pulls them. They call this pull gravity.

Sir Isaac Newton was a scientist who studied a great deal about gravity. He learned that the earth is not the only body that has this power to pull things. He learned that the other planets, and the moon, sun, and stars, can all pull things toward them. He called this pull the pull, or force, of gravi-

tation. Newton learned that larger bodies pull with greater force than smaller bodies. Also, that bodies close together pull more than when they are far apart. This means, then, that all the stars are pulling one another. But since they are so very, very far away from one another, their pull is not very great. Usually it is very, very, small.

STARS TRAVEL IN GROUPS

As you look out upon or travel over the earth, it seems a very large place. But it really is only one very small part of the universe.

You know that the earth is one of the planets that travel around the sun, and that the sun and its planets are a group called the solar system. But the solar system is only one very small part of a much larger group of stars called the Milky Way galaxy. This galaxy is shaped somewhat like a watch or flat cooky and is made up of millions and millions of stars which are traveling together in space.

Some scientists think that this galaxy is so large that there are about 30,000 million stars in it. And all these stars are scattered so far apart that it takes light several or many years to travel from one star to another. Can you imagine how large such a group must be if it is made up of 30,000 million stars separated from each other by millions and millions of miles?

Since the solar system is in the Milky Way galaxy, you are in it, also. Almost all the stars you see as you look out away from the earth at night are in this star system. With your eye alone you can see about six thousand stars in all, or about twenty-five hundred at any one time. But these are only a few of the many millions of stars in the galaxy. Others are so

Mount Wilson Observatory

This is the way our galaxy probably would look if you were out away from it and could see it on its edge

far away that you cannot see them with the eye alone. But if you could look through a telescope, you could see many, many more stars. If you do not use a telescope, their lights, in one part of the sky, all seem to blend, or shine together, and they look like a white streak across the sky. The Milky Way is the name by which you know this streak. On moonlight nights it is quite dim, but on clear, dark nights it may be clearly seen extending across the sky from north to south.

It looks like a streak across the sky because you are inside of this "watch" or "cooky" of stars. As you look upward you are looking through the thickest part of the watch or

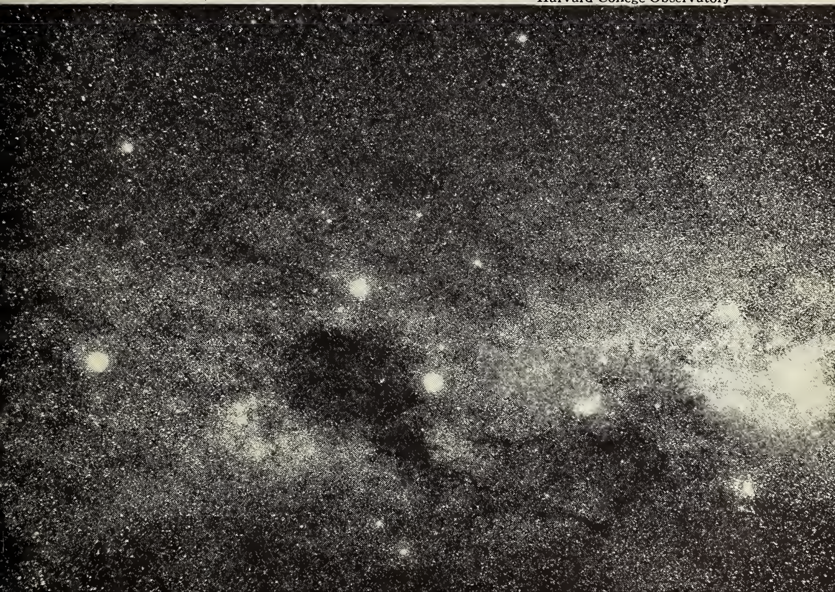
cooky. It is as if you were sitting on a spoke of a wheel looking at part of the rim of the wheel. You see so many stars that they look like a white streak.

When you look out through the sides of this "watch" of stars, you are looking through the thinnest part of the galaxy, and you see fewer stars. There are not enough stars to make that part of the sky look white.

Our Milky Way galaxy is only one of many galaxies, or large groups of stars. Some of the points of light in the sky which look like stars are really other galaxies. Most of them are so far away that they cannot be seen without a telescope. Some scientists believe that there are about 100 million of

Since you are inside the Milky Way galaxy,
this is the way it looks to you as you look toward its edge

Harvard College Observatory



Mount Wilson Observatory

If you were out away from our galaxy and could see its flat side, it probably would look quite similar to this spiral galaxy

such groups within the reach of modern telescopes, and that there are others out beyond.

Sometimes these galaxies are called spiral galaxies, because they seem to have a spiral appearance when you look at their flat sides. That is, they look as if they had been wound around and around, as is shown in this picture.

Not all of them are so flat as our galaxy. Some are shaped somewhat like an orange, flattened a little at each end. Others have a shape more like that of a ball of mud that has been pressed between the hands. But most of them are thought to be round and flat like cookies.

If you know where to look in the sky, you can see several of these galaxies which are known also as nebulae. One is the Nebula of Andromeda, which can be seen in the constellation known as Andromeda. It is oval-shaped; but if you look at it without a telescope, it looks like a fuzzy spot. It is about 900,000 light years away from the earth, and some men think it has at least 2000 million stars in it.

There are some objects in the sky that are called nebulae which are not like the galaxies known as nebulae. Some of them have great quantities of gases mixed in between the stars. Usually the gases are nearer the center, and the stars are nearer the edge, of each of these nebulae. Other nebulae seem to have no stars in them at all, but are composed of great quantities of gases that shine.

There are still other nebulae which are composed of dust and gas and do not shine at all. They are called dark nebulae. These nebulae are not so large as the galaxies. Some of them are found in our own galaxy, and perhaps in other galaxies also. They shut off the light of the stars that are beyond them, and when you look at them through a telescope, that part of the sky looks dark.

Scientists study about the galaxies and learn many things about them. They know that all the stars in each of these groups are moving. They know also that each whole group is moving. As the galaxies travel through space, they seem to be spreading out away from one another, getting farther and farther apart. This would make it seem that the entire universe, with all its galaxies, is expanding or becoming larger every second. Just how far it can expand and how large it can become we do not know. It is just one of the many things that are as yet not known.

THINGS TO THINK ABOUT

1. What would happen to everything on the earth if it suddenly received all the light and heat which the sun gives out? Or what would happen if the sun were as near the earth as the moon is? or if several other stars were as near the earth as the sun? The living things on the earth are adapted to the amount of heat and light that they now receive from the sun. This amount is likely to remain nearly the same for many, many years.

2. Can you imagine what the earth would be like if it had no gravity?

3. Your weight is the measurement of how much the earth pulls on your body. If the earth were heavier, its pull on you would be greater and your weight in pounds would increase.

4. Men have learned that the universe is very much larger than people thought it was three or four centuries ago. Then they knew only five planets and thought there were about four thousand stars. They did not know there were any such things as galaxies. Today men know there are at least nine planets and many galaxies with millions and millions of stars in each. Much more may be known when men have used larger and newer telescopes.

5. Men have flown airplanes around the earth in a very few days. But the universe is so large that, if it were possible, it would take them millions of years to fly to the nearest star after the sun. Think how much longer it would take to reach the stars farthest away.

6. All stars travel in groups as they move through space.

THINGS TO DO

1. Make a chart showing how long it would take an aviator, making a nonstop flight, to go to some of the nearest stars.

2. If it takes a thousand years for the light of a star to reach the earth, find out how many miles the star is away from us.

3. Drop a hundred peas or pebbles, one at a time, just a second apart, into a pan. How long does it take you? If you dropped a million peas into the pan in this way, it would take you about eleven and a half days. Think how long it would take you to drop a thousand million peas.

4. Have you ever watched an automobile wheel spin in the mud or pass by on a wet pavement? Have you seen the mud or water as it flew off the wheel? Pick up a stone and, holding it in your hand, whirl your arm around and then let go of the stone. What happens to it? As long as you actually hold the stone in your hand, it stays there. But the moment you let go, it starts off. Newton watched the moon as it went around the earth. He knew that it moved at a very rapid speed as it revolved, or traveled, about the earth. He wondered why it did not shoot off as your stone does when you let go. He decided that the gravity of the earth pulled the moon and kept it from going out into space.

II

Birth of the Solar System

WHAT MAY HAVE HAPPENED TO THE SUN

HOW THE SOLAR SYSTEM CAME TO BE

AN ATMOSPHERE AND OCEANS WERE FORMED

FROM the very earliest beginnings of science men have tried to learn where the earth came from and how it got here. In order to find out these things scientists have watched the movements of the stars and have thought and studied much. They have made telescopes and other instruments to aid them in their study. They have learned many things about the sun and other stars; what these bodies are made of and how they shine and move. Scientists have learned many things which help them to answer the questions where the earth came from and how it got here.

By using all their knowledge of the stars, men have worked out explanations of how the earth and the entire solar system may have been formed. If an explanation seems to be correct, scientists call it a hypothesis. Sometimes a hypothesis seems to be all right for a time; but, later, scientists may find it is not entirely satisfactory. Sometimes they change it or work out another explanation. If it proves to be a better hypothesis, scientists are willing to accept it and try it out. If, in time, it seems to be very good, scientists begin to think it may be the true explanation. Then they call it a theory.

In the next few pages you will read some of the hypotheses about how the entire solar system may have been formed.

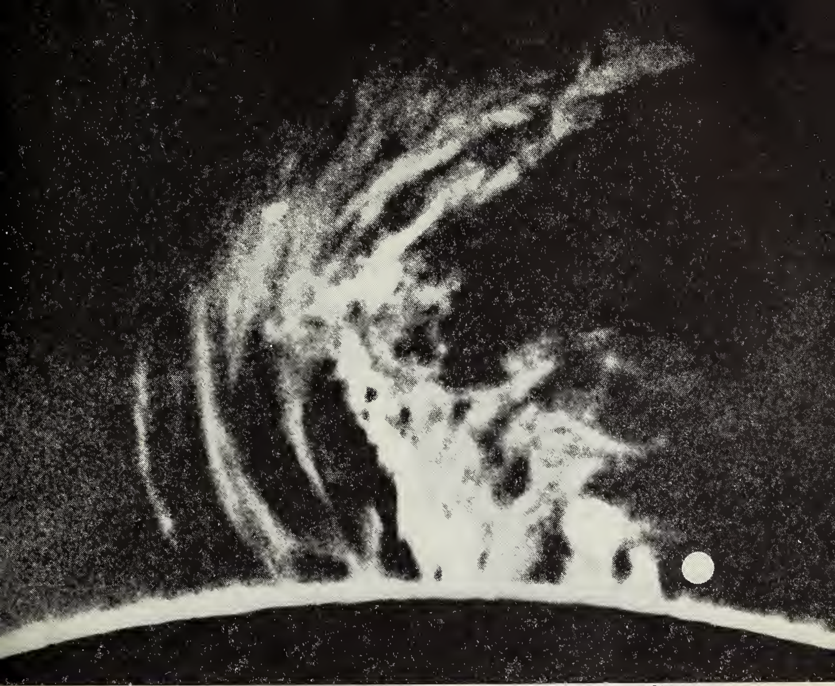
What May Have Happened to the Sun

Sometimes men have had one idea about how the solar system was formed, sometimes they have had another. Often they have kept the parts of one explanation that seemed good and have added to them in order to make a better explanation. For example, most scientists agree that at one time the sun may have been larger than it is now. They think also that the planets came from the sun. From that they have tried to explain what may have caused the planets to break away from the sun. Even yet, men do not know whether they have the correct explanation, because men have not yet learned everything there is to know about the universe.

For a long time certain men believed that once, when the sun was somewhat larger than it is now, it was rotating, or turning, very rapidly. In fact, they thought it was whirling so rapidly that it could not hold all its material together. Finally some of the material broke away and later formed planets.

Other men have thought that a very large star exploded and shot off gases. They thought that some of these gases later formed spheres that began to revolve about the central part. The part of the star that remained was supposed to be the sun. For one reason or another, scientists today think that this and certain other explanations are not altogether or entirely satisfactory.

There is now one explanation that many scientists think is better than any of the others. It is sometimes called the passing-star theory. This theory starts with the idea that once, in the long distant past, our star, the sun, was larger

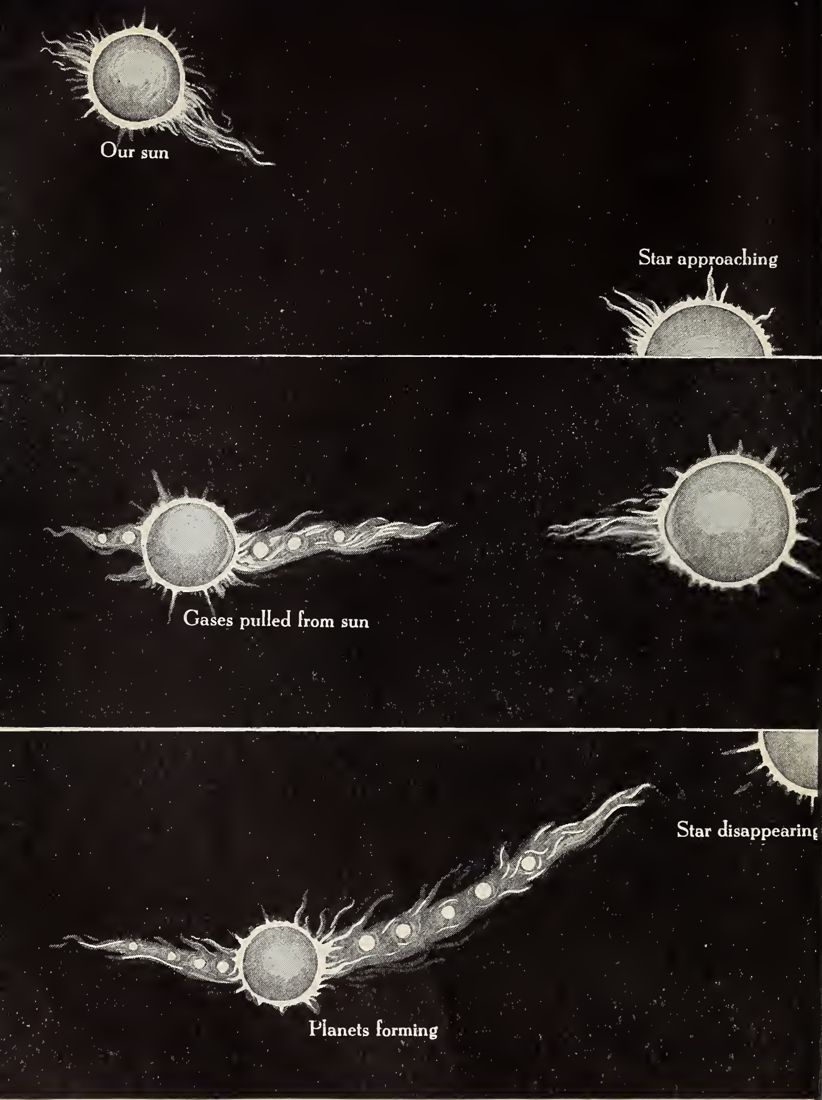


Mount Wilson Observatory

Photographs show that streamers of gases sometimes shoot out thousands of miles from the surface of the sun. Compare their size with the size of the earth, shown as a small white sphere

than it is now, and that it was moving through space just as it had done for a long, long time. Another star, too, was moving in its own path, but was coming toward the sun.

At first the sun and the other star were very far apart. From the sun, at that time, the other star would have looked like any other star in the sky, just a mere point of light. But as time went on, our sun and the other star drew nearer and nearer together. Finally, after a very long period of time, they were so near to each other that, looking from the sun,



Some scientists think that this is the way the gases which formed the planets were pulled out of the sun

the passing star would have appeared as a very bright light, probably larger and brighter than our sun looks to us now.

Had you been somewhere near, looking at this unusual event, you would have seen two suns, instead of one. You might have thought that these stars would crash together. Perhaps they did. Some scientists say they only grazed each other. Other scientists say the stars did not hit each other at all, but that they were at least as far away from each other as Pluto, the farthest planet, is from the sun.

At first the force of gravitation between the two stars was very small. But as they moved toward each other the pull between them became greater and greater. While this was going on, each star was turning rapidly on its own axis.

As is happening today at the surface of the sun, its gases were rolling and tumbling, and fountains of gases were spouting out from its surface. As the two stars moved closer together, more and more of the sun's gases began to roll and tumble, and the fountains became great mountains of gases. At the same time the sun was probably pulling great mountains of gases from the other star. Had you been watching, you would have seen the gases pulled so high that the sun was stretched out of shape. For a long time the sun continued to hold its gases together. Sometimes when large amounts of gases almost left the sun, it pulled them back again. But finally when the stars were closest together, the force of the other star was too great for the sun, and great quantities of its gases were pulled from it.

The total amount of gases pulled from the two stars was very, very great. Possibly some of the gases were pulled back into both stars. Some of the sun's gases may have been pulled into the passing star. But scientists think that part of its gases remained outside the sun in one or two long

curved streamers, or arms, of gases. One scientist thinks there was one long streamer in the shape of a cigar, with the greatest amount of gases at the center. These gases continued moving in the same direction as the sun and probably began to curve around it. You will see later how planets may have been formed from this gas.

All this time the two stars continued to move. After they had passed each other, they moved on and on, and became farther and farther apart. The other star went on its way, and, as it did so, its pull became less and less. What happened to it we probably shall never know. The gases which were pulled from it may have formed planets, and the whole group may be another solar system out in space.

However, some scientists have not been entirely satisfied with all of this passing-star theory. They have added a few more explanations to it. These scientists think that in the beginning our sun was a double star, that is, two stars held near each other by the pull between them. These men think that a third star passing by may have bumped into the sun's twin star. If so, great quantities of loose gases were probably scattered about the three stars. After they had bumped into each other, the passing star and the sun's other star shot off in different directions. Possibly each star took some of the loose gases with it, which may have formed planets around the star. But the scientists who believe in this theory think that part of the gases was held by the sun and caused to revolve about it, thus forming the planets of our solar system.

Some people like this theory. They think that in some ways it is better than the older theories. But we do not have enough proof to say that any explanation so far given is altogether correct. Scientists are still searching for more

knowledge which may help them to learn the true explanation of how the solar system was formed.

THINGS TO THINK ABOUT

1. Scientists think that the earth was a part of the sun millions and millions of years ago.

2. Had you been somewhere out in space, gazing at the sun and the approaching star, you probably would have seen them pass some millions of miles apart, pulling great amounts of gases out of each other.

3. Men have had many different ideas about the earth and how it was formed. Often, as they have learned more about the stars and their movements, they have been able to give better explanations. As they learn still more in the future, they may be able to give still better explanations of how the solar system was formed.

4. Scientists study and take pictures of the sun during its eclipses, when the moon is between the sun and the earth. They see long streamers of gases which shoot out from the sun and then fall back. They know that the gases on the surface of the sun are never at rest; that these gases are always rolling and tumbling, and shooting out in streamers, as they probably were doing at the time the planets were pulled from the sun.

5. Although the amount of gases pulled from the sun was great enough to form the planets, still it was only a small part of the sun.

THINGS TO DO

1. Watch in magazines and newspapers to see if anything more is found that seems to prove any one explanation of how gases were pulled off from the sun. Read any new explanations and see if scientists think they are better.

2. Read about any new invention which you think may help scientists to learn more about what happened to the sun.

How the Solar System Came to Be

THE PLANETS WERE FORMED

Some scientists think that the planets were formed in the following way from the gases pulled from the sun: When the gases left the sun, they had a great amount of space around them. They had more space around them than when they were part of the sun; so they spread out. As they did this, the thinner parts of the streamers cooled rapidly and became small, solid pieces of rock and dust, called planetesimals. The thicker parts did not cool so rapidly, but formed into knobs of materials, which began to separate from one another and to form spheres. As they did this, they began to collect big clouds of the dust, or planetesimals, which were about them.

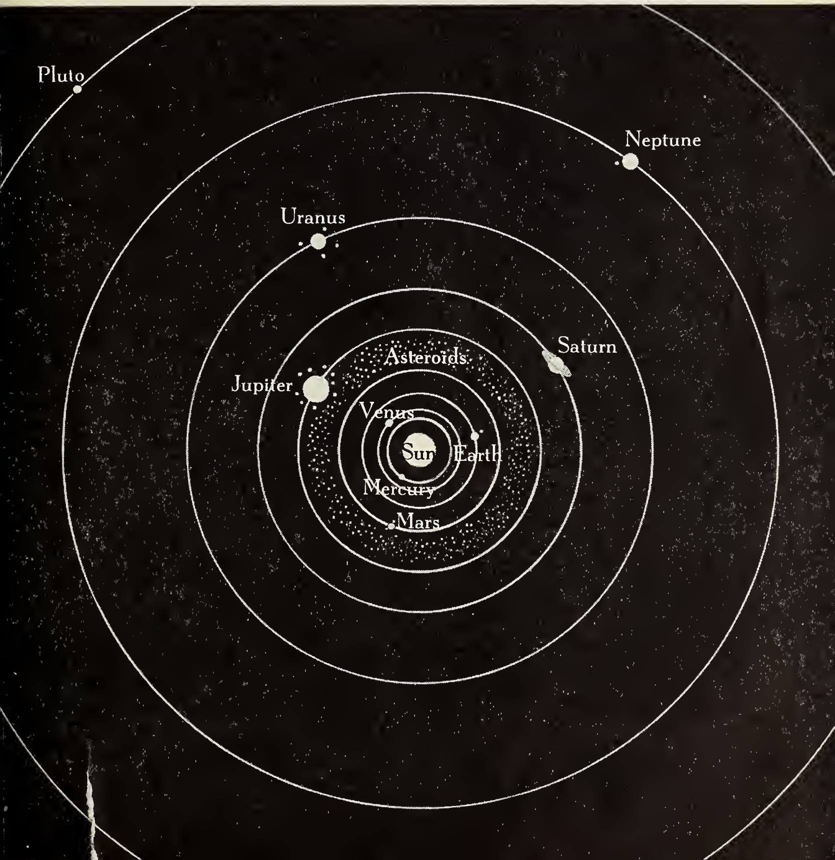
As the thickest knobs traveled around the sun, they passed through the clouds of dust and small bits of rock, and they grew by pulling some of these pieces to them. As long periods of time went by, the knobs became still larger. The more pieces these knobs drew to them, the larger they grew, until they became small planets, not yet so large as they are now. Some men say that at first our earth was only one tenth of its present size.

Many scientists do not agree with the planetesimal hypothesis. They have another, which to many people seems a better one. These men say that the planets have not grown at all, but that they had their present size almost from the beginning. They believe that the gases pulled from the sun were divided into ten or more parts very soon after leaving the sun. Nine of these parts formed the nine known planets. The other part formed the asteroids, which are very small

bodies that travel around the sun between the paths of the planets known as Jupiter and Mars.

No one knows exactly how these parts formed the earth and the other planets. But some scientists think that this is the way one part became our earth: After it had become separated from the others, the knob or sphere of gas which finally

The planets and their moons, which now travel about the sun, probably were once part of the sun



became the earth continued to turn on its axis and to travel around the sun. As it did so, it began to cool. Small parts cooled until they became liquid rock. Since they were liquid, they were heavier than the gas around them, and they sank to the center of the sphere. Other small parts cooled to liquid drops and they too fell to the center. Little by little the amount of melted rock at the center became larger and larger. Finally, after the earth had cooled a very long time, it became solid.

Whether this was the way the earth came to be as it now is we do not know, but scientists have experimented and believe that the earth is solid. They think that in the center there is a very large mass which is mostly iron and nickel. Outside this there is a layer of common rock materials mixed with iron. The next outer layer is mostly common rock materials. The top layer, or surface, is very thin compared with the other layers.

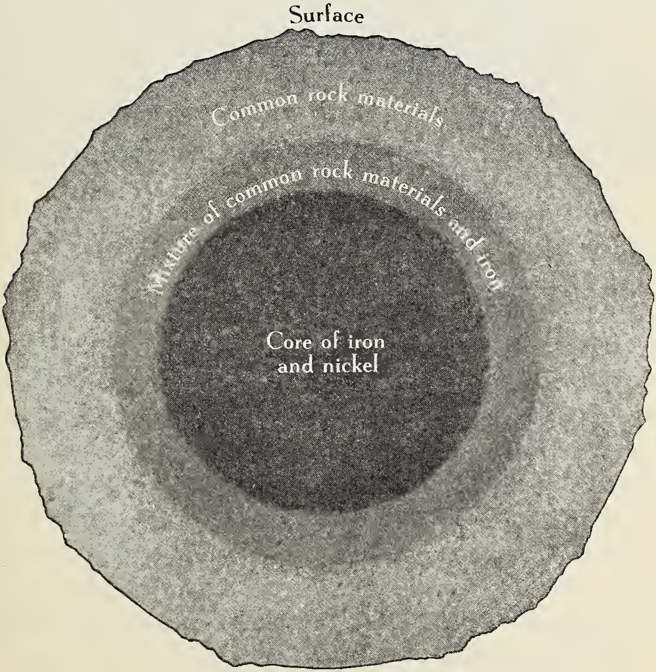
When the spheres first separated, they did not have regular paths. They may have wobbled around the sun, first going closer to it and then farther away from it. It is thought that possibly while they were first wobbling in this way, some of the planets went very close to the sun or to each other. As they did so, material was pulled out of them just as they themselves had been pulled out of the sun. This new material drawn out of certain planets began to travel about them somewhat as they had traveled about the sun, and it formed one or more moons. So our moon is believed once to have been part of the earth. As the spheres, or planets, with their moons continued to travel about the sun, their paths became more as they are today.

If our solar system was formed because one star passed very close to another, there may be other solar systems simi-

lar to ours. If such an accident happened once in a universe of stars, it may have happened more than once, and there may be other solar systems in the universe. But as yet no other solar system is known.

Many ideas have been given in the past about our solar system. These ideas have changed many times as more and more facts have become known. When men have had an opportunity to make studies with better telescopes, many new things about the solar system and the universe may be discovered.

Scientists think that the earth is made of these layers



COMETS MAY HAVE COME FROM THE SUN

There are other things that may have been formed from the sun. Some of them are comets. You know that a comet looks like a ball of light with a blazing tail. Comets are not really blazing. They shine because they reflect the light from the sun.

Comets are made up of dust, gases, and small pieces of rock, which are held together by their pull on one another. The pieces of dust and rock which form the tail of a comet are very small and are far apart. The tail is so thin that stars at times may be seen through it.

Scientists think that the small pieces of rock and the dust and gases which make up the comets probably came from the sun. Some of the comets may have come from the sun in the same way in which the planets came. Perhaps they came at the same time. Possibly they were formed from some of the gases that were lost immediately and began traveling in space by themselves. Many pieces of rock and dust, going in the same direction and at the same speed, were drawn together and formed groups. Some of these groups may have been the beginning of comets.

Other comets are thought to have been made of materials shot out from the sun at different times, in much the same way that lava, gases, and steam are shot out from volcanoes. At times of eclipses men see great arms of gases, sometimes hundreds of thousands of miles long, shot out from the surface of the sun and then pulled back into it. This was shown in the picture on page 41. Perhaps not all the material shot out is again gathered into the sun. Such material is lost in space. Perhaps years ago similar streamers were thrown out to a greater distance, and even more of the gases were lost. These may have formed other comets.

Yerkes Observatory

This is Brooks's comet. Notice the dense head and the thinner tail

WHY THERE ARE METEORS

No doubt you know by now that "falling stars" are not stars at all, but meteors; also, that there always are these little bits of dust or pieces of rock moving about in space in all directions. They cannot be seen except when they come into our atmosphere and burst into light and streak the sky for a second or two. Do you know where they come from? Probably a great many of the meteors came from the sun at one time or another.

You remember what happened, or at least what scientists think may have happened, when the solar system came into

LIBRARY OF THE UNIVERSITY OF ALBERTA

Yerkes Observatory

The bright line was made by a meteor which streaked across the sky. It probably was only a very tiny piece of rock

being. Part of the material pulled from the sun formed planets; another part formed comets; but other parts formed bits of dust and pieces of rock which travel around the sun in their own paths. It is probably some of these which often brighten our sky for a moment and are gone.

Still other small rocks and bits of dust may have formed from material thrown off from the sun in some of the long streamers that we know are always being pushed out from its surface. Other pieces may have drifted in from outside the solar system.

It is thought also that there are bits of rocks traveling

about the sun that may have come from the comets which were broken up when they went too near the sun. Can you think of some reason for believing this? Scientists tell us that groups of meteors are known to travel around the sun in nearly the same paths as some of the comets did before they were broken. At certain times of the year the earth moves into or near great swarms of these meteors. At such times you can see many more meteors than you usually can.

As the cold meteors rush through the air around the earth, friction with the air, or rubbing against it, makes them so hot that they change into gases. The gases that are given

The meteorite which the man is holding in his hand fell through the roof of the garage and passed on through an automobile before it stopped. It is about four inches in diameter

Field Museum

off are so hot that they shine for a short time. Meteors give off a very bright light and may seem to us large and dangerous. But usually they are very, very small.

Sometimes, however, meteors similar to the one in the picture on page 53 are large enough to reach the earth before they have changed completely to gases and dust. Then they are called meteorites. Scientists have examined meteorites in order to learn as much as possible about them. Most of them are made of iron, with some nickel and another metal called cobalt. A few, called stone meteorites, have been found which are made of rocky materials.

There are a great many things about the solar system which scientists do not know. But many scientists believe that the planets with their moons, comets, and meteors at some time or other were part of the sun. They are scattered about the sun and go with it in its travel through space.

THINGS TO THINK ABOUT

1. Although it has been millions of years since the birth of the solar system, and many years since men first began to study the universe, much of what men know has been discovered in the last two or three centuries.

2. Why do some people think that there may be planets revolving about other stars, forming other solar systems? Could the same thing that happened to our sun have happened to other stars? If so, it probably would not happen more than once in many, many millions of years.

3. How many kinds of bodies may be found in the solar system? At one time they all may have been part of the sun.

4. Which planets have moons? Scientists think these planets passed near enough to the sun or other planets to have moons pulled from them. Some of the moons are quite large; two of the planet Jupiter's moons are as large as the planet Mercury.

5. Some people used to fear comets. They thought comets were a bad sign. Other people studied comets to find out what they were and when to expect them.

6. Some scientists have thought that the planets were very much smaller when they were first formed than they are now. Others think they were about their present size.

7. Small swarms of meteors often occur in August and in November. It is thought that during these months the earth passes through or near two broken-up comets.

8. Several very famous meteor showers have occurred at different times in the earth's history. One was in 1833, another in 1866. On October 9, 1933, a third great meteor shower occurred in Europe, and brightened the sky for several hours. These were probably caused by the earth's passing through broken-up comets.

THINGS TO DO

1. Watch in magazines and newspapers to see if anything more is found that seems to prove any one theory of how the earth was formed.

2. Count the meteors that you see some evening in any one period of time. Count again about August 10. Was there any difference in the number you saw in the same length of time?

3. Visit a museum and look at some of the meteorites that have been found. The same kinds of materials which are in the meteorites are also to be found in the earth and the sun.

4. Write a story about all the things that might have happened to a meteorite. You might name your story "A Meteorite and Its Travels."

How gases may have been added to our atmosphere:
hot rocks; volcanoes; plants and animals; fires

An Atmosphere and Oceans Were Formed

GASES COLLECTED TO FORM AN ATMOSPHERE

Those scientists who believe in the planetesimal hypothesis think that the earth at first was too small to hold an atmosphere. They think that as the earth grew and grew it was able to pull and hold more and more gases to it. Some of these gases, they say, were pulled in from space just as the planetesimals were pulled in by the earth. Other gases, they think, came from the meteors that became hot and changed to gases as they fell. Still other gases are thought to have been added later from volcanoes.

The scientists who believe in the other explanation, sometimes called the tidal theory, think that most of the gases of the atmosphere were in the material that was pulled from the sun. They think that as the earth began to cool some of these gases collected at its surface. Perhaps some of the hot melted rocks had water vapor and other gases held in them. Slowly, as these rocks cooled century after century and became more solid, the gases may have escaped and risen to become part of the layers of gases which formed an atmosphere around the young earth.

Probably other gases have been added to this first atmosphere during all the ages down to our own time. Some have been added to it from the eruptions of volcanoes and hot mineral springs. Others, in recent years, have come from the smoke of burning fuel and other substances. Decaying substances have added other gases. All these have helped to make our atmosphere what it is today.

If the earth had no atmosphere, there could be no plants or animals living upon it. An atmosphere is absolutely necessary for life as we know it. Animals must breathe oxygen from the air in order to live; plants must have carbon dioxide and oxygen to live and manufacture food. If there were no air, no rain would fall, and no wind would blow. Without the air, the earth would become very hot by day and very cold by night. There would be no clouds, no rainbows, no beautiful colors in the morning and evening skies. From these you can see that an atmosphere is very important. Since there is an atmosphere, there are clouds, and winds, and rains, all of which help to make the earth a place of beauty and a good place in which to live.

WATER GATHERED INTO LAKES, SEAS, AND OCEANS

At first the earth was too hot for water or rain to form. All the water was steam. Some of it was in the atmosphere that was forming, and some of it was held in the rock materials which were so hot that steam could not cool and change into water vapor.

But as the earth cooled slowly, century after century, there came a time when steam high above the surface of the earth began to cool enough to form tiny bits of water vapor. Finally, after a long time, enough water vapor was formed to make heavy clouds, which gathered around the earth. Even

yet, it was too hot on the surface of the earth for the water vapor to fall as rain. But after thousands and thousands of years the first rains fell upon the hot rocks of the earth. Possibly at first the earth was so hot that the water was again changed to steam as it fell. But there came a time when rain began to fall and collect upon the earth.

The rain fell upon the tops of hills and in the valleys, on the hillsides and on the flat open country. It rained and rained. As it fell, it ran off higher places and gathered into little pools. Little pools became full and overflowed. Perhaps as they overflowed they ran into other pools a little larger. They in turn were filled and gathered into still larger pools. As this continued for thousands of years, pools of water slowly became ponds, lakes, and seas.

Perhaps some water did not at first collect in pools but ran down slopes and through low places, forming tiny streams. As it continued to rain, these little streams became larger. They met other little streams flowing in the same general direction. They continued to flow, following the lowest places and joining with other streams, until rivers were formed. Rivers then emptied into still lower places and so helped to form lakes and seas. It may be that other rivers flowed to large, low basins and started to form oceans.

Rains followed rains until, after thousands and thousands of years, these great basins were filled with water. Notice the maps on pages 58 and 59 and you will see that about three fourths of the earth's surface is now covered with water.

During all the years that water has flowed over rocks it has been dissolving some of the substances in the rocks. As it has done so, it has carried these dissolved materials into seas and oceans, where they have collected. Probably the most common substance which was dissolved is salt. Some

of the salt in the oceans is the same kind of salt that is used in your food. There is not enough salt in river water for you to taste, but in the millions of years that rivers have brought water to the oceans they have carried tons and tons of salt with them. Water is always evaporating from the oceans, but the salt and other dissolved substances must remain. That is why the oceans are salty.

There are lakes that contain a great amount of salt or another substance called alkali. Some of these lakes were formed when an arm of the sea was cut off from the sea itself, when parts of the land were raised. Others, such as Great Salt Lake, were formed in valleys or low places which were fed by snow and rain from the surrounding mountains, and as they had no outlets, their water, like that of the oceans, became very salty.

THINGS TO THINK ABOUT

1. Why are we interested in the earth's atmosphere? Is it necessary for the life upon the earth?

2. Why could there not be rain if there were no atmosphere?

3. Great salt beds have been found in different parts of the world. Tell how some of them were formed.

4. Why did not soil soak up these first rains?

THINGS TO DO

1. Tell how some lakes have been formed. Why did not all the water flow to the oceans?

2. Locate the oceans of the world and show where the water comes from that empties into them. Water has been collecting in these oceans for millions and millions of years. At the same time that water has been collecting, it also has been evaporating.

3. If there is a salt mine near you, visit it and try to learn how the salt happened to be there.

III

Our Changing Earth

THE EARTH HAS CHANGED IN
APPEARANCE MANY TIMES

VOLCANOES HAVE CHANGED THE
SURFACE OF THE EARTH

MOUNTAIN FORMATION AND EARTHQUAKES

IT HAS been a great many years since the gases which formed our earth left the sun, more years than anyone can even imagine. It seems a long time since the Pilgrims first landed on Plymouth Rock or since the French first settled in Canada. It seems much longer since Columbus discovered America. It was long, long before then that men had only stone tools with which to work. But any of these lengths of time are almost as nothing compared with the very great age of the earth. Some scientists think that the earth itself is over two thousand million years old.

The earth has changed in appearance many times in those two thousand million years. Many times the bottoms of seas have been pushed up to become the tops of mountains, and mountains have sunk into the seas or have been worn down and carried to the seas. Rivers have come and gone, some have changed their courses, and some that at one time flowed north now flow south.

Changes in climate have caused great changes in some places. Once Greenland had a warmer climate than it has now, and may have looked similar to the picture on page 64. Now the climate is much colder, and you can see how the country has changed to look like the picture on page 65.

Scientists know that these changes have taken place and have studied about them. They tell us what may have caused many of the changes which have made the earth what it is.

The Earth Has Changed in Appearance Many Times

The earth is not quite the same today as it was yesterday. It will not be quite the same tomorrow as it is today. Volcanoes are changing the earth in one way. Other forces are changing it in still other ways. These changes which are occurring have been going on for many millions of years.

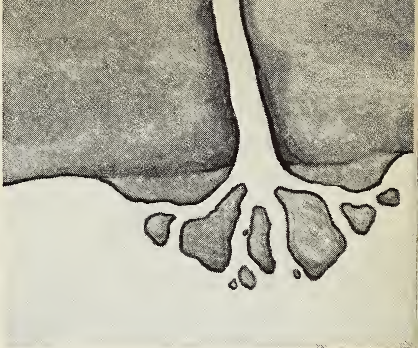
Perhaps one of the most regular and important changes which have been brought about has been in the changing of the great bodies of land on the earth which are known as continents. Had a map of the world been made millions of years ago, you would not recognize the continents as you know them. Their shapes have never remained the same, but have changed slowly many times.

These changes have been partly caused by the wearing away of soil. Waters have worn down mountains and hills and have carried great amounts of soil to the seas and oceans. At the mouths of the rivers this soil carried by the water settled and collected to form deposits known as deltas. We call soil that has settled in water, sediment. Each time a delta was formed by such sediment, the shape and size of the continent were changed.

This sediment had other effects also. During all the years that sediment was deposited, it was adding to the weight on the ocean floors. When this weight became great enough, it caused the floor of the ocean to sink in places.

As places in the ocean sank, it caused a greater pressure below that part of the ocean floor. This pressure caused the surface in other places to rise. If you press down on a toy balloon, it bulges or pushes out in places where you do not

his shows how sediment has started to collect at the mouth of a river



After great amounts of sediment have collected a delta is form

press. In much the same way the sinking of the ocean floor caused continents to bulge out in other places. Even now parts of the coast in different places are sinking into the ocean, and other parts are being very, very slowly pushed up. So slowly do these changes take place that it is only after many years that any change can be noticed.

Since the earth's surface has sunk in some places and risen in others, it is quite uneven. In some places it sinks below sea level, and in other places it rises far above it. The continents of the earth rise to an average height of about 2400 feet above sea level. Scattered over these continents or in mountain ranges are peaks of different heights. Mt. Everest, which is the highest of all, rises more than 29,000 feet, or about five and a half miles, above sea level.

On the other hand, the ocean beds have an average depth of about 13,000 feet below sea level. Just as there are peaks on the continents, there are great depths in the oceans. There is one place in the Pacific Ocean, north of Mindanao, Philippine Islands, which is more than 32,000 feet, or over six miles, deep. The greatest known depth in the Atlantic Ocean is about 27,000 feet, or over five miles.

These depths and heights which seem so great to us are so small compared with the great size of the earth that if we could look at the earth from a distance it would appear only slightly wrinkled.

Another change in the surface of the earth has been in the changing of rivers. As the movements of the earth's crust have caused the surface to rise in some places and fall in others, they have caused new rivers to form and old rivers to change their courses.

Floods too have caused rivers to flow in new river beds. Have you ever noticed the changes in a bank of a river? Notice that the moving water often wears away the bank on one side and builds a sand bar on the other. Slowly the course of such a river changes. Sometimes during a flood a river leaves its banks and takes a short cut. Afterwards it may follow the short cut and leave its old course entirely.

The picture shows how a river has changed its course around an island. Only a few years ago almost all the water flowed on the left side of the island, between what looks like two rows of trees. After a flood most of the water began to flow around on the right side of the island. Now it is still changing its course and its banks by cutting away the point near the center of the island.

Great changes in climate have taken place in the past and are probably taking place now, but so slowly that you can scarcely recognize them. In some places the amount of annual rainfall has increased, in others it has become less and less, in each case affecting or changing the country. Some lands which yield fine crops today were once deserts which produced almost nothing. The northern part of Africa, which had enough rainfall to produce grain in the early history of man, has since become a dry country in which little grows.

It is difficult to believe that some places which are now thick with plant and animal life were once covered with ice. But at several different times there have been widespread glaciers over many lands. Many years ago a great sheet of ice covered part of the territory which is in the United States and Canada, while another ice sheet covered parts of Europe. We may be quite sure that parts of Africa, Australia, and India have been covered by ice at certain times in the past. If you could look at the plants and animals living in these places now, you would never guess that once ice had been there.

In some of the very coldest regions of the world, where there is nothing but layers and layers of ice, plants once grew

Read the text to learn how this river in Kansas has changed its course

Barnes Aerial Surveys

in great quantities. They were so thick that the sunlight could scarcely find its way through the leaves and branches. These regions were like a jungle. Ages afterwards many of the plants which had grown there so thickly were changed to coal. Some of this coal has been discovered and is one proof that plants lived in these cold regions in the past.

These are only a few of the ways in which the surface of the earth has changed. But there are other ways. Changes are taking place everywhere, every day.

THINGS TO THINK ABOUT

1. The place in which you live has changed a great many times in the past and is still changing. Can you see ways in which changes are slowly taking place? Have any changes taken place during your lifetime?

2. The altitude of any place is its height above sea level. What is the altitude of the place where you live? Can you find out if it has ever had a different altitude?

THINGS TO DO

1. The highest mountain peaks on the earth are a little more than five miles high and the greatest known depth in the ocean is more than six miles. This makes a difference of about twelve miles between the highest and lowest points on the earth's surface. Compare this with the nearly eight thousand miles of the diameter of the earth. By doing so you will see that the earth's surface is only slightly uneven. Make a chart or clay model of a cross section of your country, showing the differences in altitudes in the mountain and plain regions.

2. Find out about the place where you live. Was it once under water? Can you find any shells or anything which shows that it was once covered by a sea? Was there ever a mountain there?

3. If a river flows near you, find out if it has always flowed the same way. Can you find an old river bed where the river once flowed?

Volcanoes Have Changed the Surface of the Earth

Scientists have studied and experimented, or worked, to find out what has happened to the rocks of the earth since they became cool. Some say that some of the rocks did not remain solid. They think that these rocks again became hot and some of them, only a short distance below the surface of the earth, melted.

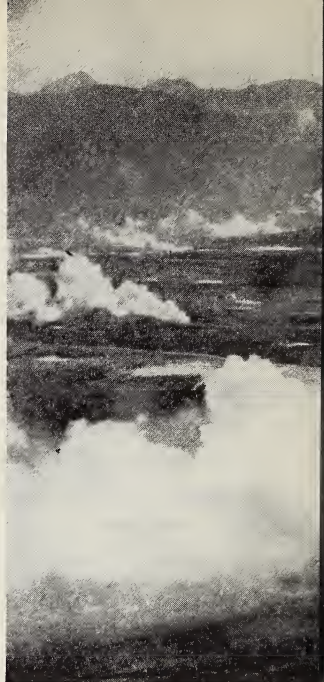
Scientists have learned that rocks become hot when there is a great deal of pressure on them. It may be that as the earth became older it began to shrink and wrinkle. This and other movements of the earth may have caused the rocks at the surface to press more and more upon the rocks below, until they became hot and melted.

There may have been other causes for the heat that melted the rock. Perhaps you have heard of radium, which is sometimes used by doctors. In the earth there are several substances, such as radium, which are always changing in such a way that heat is slowly given off. This change has been going on through all the ages, and a great amount of heat must have been given off. The heat caused by this change, as well as the heat caused by the pressure of rocks from above, was stored up in the rocks in great quantities.

Some substances become hot quickly and cool quickly. But rocks become hot slowly and then hold the heat for a long time. Because of this, the rocks under pressure finally became so hot that some of them melted. Certain rocks melt more easily than others, and some of them melted and formed pockets of hot lava. Such pockets lay in solid rock that did not melt.

As some of the rock became hot and melted, it expanded, that is, it needed more space; and so it pushed its way through weak places in the nearest layers of rock. In this way the melted rock sometimes slowly pushed its way up toward the surface of the earth. Sometimes it became hard before it reached the surface. But often it found a weak layer of rock through which it burst and poured out over the land.

Such melted rock, or lava, may flow out in streams, miles in length, from a hole in the surface of the earth, or it may pour out in sheets and spread over many square miles in area, forming lava fields.



Looking across part of the Valle

At places where it has poured from a central point many times throughout the years, it has built up a cone-shaped mass around the opening. From time to time not only lava but ashes, pieces of solid rock, and gases burst forth. These cone-shaped hills or mountains are volcanoes.

Volcanoes are located most often near points in the earth's surface that are the weakest. Quite often the points follow the shore line of a continent.

Volcanoes may be of any size and shape, from little flat-topped hills one or two hundred feet high to steep and high mountain peaks, some ten thousand feet or more high.

© The National Geographic Society. Reproduced by special permission

of Ten Thousand Smokes you see vapor and gases rising from an old lava bed

There are two kinds of volcanoes. In one, the lava flows out slowly and quietly. In the other, quantities of gases, liquids, and solids are shot into the air with enormous force. In this kind, pressure, which is caused partly by liquid rock but mostly by gases, is stored up when the volcano is not active. When there is enough pressure to open the top of the volcano, the eruption takes place.

Sometimes the eruption of these materials takes place with such force that enormous quantities of gases, water vapor, and ashes, along with parts of the mountain, are thrown out with a roar that has been heard more than a hundred miles

away. Great clouds of dust and ashes from volcanoes have at times completely hidden the sun and have remained in the air for months.

At other times the eruptions occur with less force, and the lava runs down the sides of the volcanoes and out over the land. The streams of white-hot lava slowly cool to a glowing red, taking days and sometimes months to cool from red-hot rock to cold solid rock.

In the southwestern part of Canada and the northwestern part of the United States around the Columbia and Snake rivers, great beds of lava have been found which are as much as 3000 feet deep in places and which extend over thousands of square miles. Scientists think that these fields of lava may have been formed by the addition of layer after layer of lava as it was forced out from cracks in the earth's crust, as well as by lava from near-by volcanoes.

Yellowstone National Park occupies 4000 square miles of such great lava beds. Deep underneath the surface still lie masses of hot rock, which make the park one of the greatest known regions of geysers and hot springs.

Quite often beds of this sort give off steam, a small amount of carbon dioxide, and other gases for many years while cooling. The Valley of Ten Thousand Smokes, in Alaska, shown in the picture on pages 72 and 73, is so named because of the gases rising from a lava bed that has not yet cooled completely.

THINGS TO THINK ABOUT

1. A number of new volcanoes have been recorded in human history.

a. Jarullo, in Mexico, started on a cultivated plain in 1759. From then until the present time enough lava has poured out of it to make a cone over 4000 feet high.

b. Izalco, in Salvador, erupted the first time in 1770 and has been active since then. It stands now over 6000 feet high.

2. Some volcanoes erupt with such force that they form huge pits, or craters, sometimes three or four miles across. These pits may be formed also by the lava settling back into the underground opening.

3. Crater Lake, in Oregon, is a lake which has formed in an old crater. It is about six miles long, four miles wide, and in places 2000 feet deep. In the center of the lake is a small cone. This may have been caused at some time by renewed action of the volcano.

4. There are several important active volcanoes we read about today. Cotopaxi, in Ecuador, is a very high peak over 19,000 feet high. Its crater is half a mile in diameter. Mt. Etna, in Sicily, which rises 11,000 feet above the sea, is thirty miles wide at the base of the mountain. For 2500 years that we know of Mt. Etna has been active at different times. It is probably 300,000 years old.

5. As men have gone down into the earth, they have found that the temperature increases with the depth. In some places this temperature increases faster than in others, with an average of about one degree in every 60 to 75 feet. Because of this increase, it is uncomfortably warm in some of the deepest mines. This is proof that there is heat stored up in the earth. How do you think it got there?

6. Some of the volcanic ash which helps to form the rock in Yellowstone National Park once covered trees where they stood. Some of these trees became changed to stone. Some of them have been dug out or the ash has been worn away, so that they may now be seen still standing. They show what kind of life was there before the lava covered it.

THINGS TO DO

1. Locate the volcanoes of different continents. Draw a line connecting them. Notice that they form volcanic regions.

2. Watch newspaper accounts of earthquakes and volcanic action. Do they occur in a volcanic region?

3. Make a model of a volcano. Can you make it in such a way that steam will come out at the top?

Mountain Formation and Earthquakes

HOW MOUNTAINS ARE FORMED

The forming of mountains has been one of the ways in which the surface of the earth has changed and is still changing. Mountains have been formed in several ways during all the history of the earth.

A great many mountains have been made by volcanic action. High mountains and broad plateaus have been formed by lava flows. Many of the highest mountain peaks are cones of old volcanoes.

Through the early ages in the history of the earth there were times when great volcanic eruptions took place. Each was followed by a time of rest when volcanoes would be quiet. Then more eruptions took place with the fresh, hot lava pouring over that which had been thrown out at some time in the past. This occurred time after time. Volcanic ash and pieces of rock were thrown out and added to the lava. Finally, mountains of different sizes were formed.

Strange as it may seem, volcanoes were not only on the land but also on the bottom of the oceans. Eruptions took place there as well as upon the land, and chains of mountains were formed there in much the same way as they were formed on land. The Hawaiian Islands are examples of mountains that have been slowly built up from the bottom of the sea. Their tops are 30,000 feet above the ocean floor. Many other islands have been formed in this way by volcanic action.

Many hills and mountains have also been made by the movements of the rocks which form the earth's crust. It

would be difficult to imagine any direction in which these rocks have not moved. Great masses of rock were pushed up slowly until huge folds, or wrinkles, were made, forming hills or mountains.

Some of the long and narrow mountain chains have been formed by long folds in the surface of the earth. Some such ranges stand 1000 or more feet above the lowlands next to them. Some wrinkles are as long as 170 miles and only three or four miles wide. The Appalachians, the southern Rocky Mountains, the Alps, and the front range of the Andes are mountains which were formed by long folds.

Some mountains were formed from lava which had poured out of great cracks in the earth's crust and when cooled had become great heaps of rock. Through the centuries the softer

These gases are rising from a crater under the water.

Many eruptions may cause a new island to form

United States Geological Survey

This cut in the side of a hill shows how layers of rock have been folded, forming hills and mountains. Once these layers of rock lay fla

material was worn away from the sides of the cracks, leaving a great mass of hard, cold lava as hills or mountains of rock. Mountains have been formed not only in one way, but in many combinations of ways.

The crust of the earth keeps somewhat balanced by sinking in some places and rising in others as soil and rock are worn away from one place and deposited in another. This movement is slowly taking place all the time. As some mountains are being built up, others are being worn down.

CAUSE OF EARTHQUAKES

Men have always been interested in explaining things which happen. The rainbow, the rising and setting of the sun, the tides, earthquakes, and many other things in nature have caused them to search for many "whys." Even today scientists are trying to learn more about these things. Earthquakes especially have been puzzling.

Once upon a time people would have said that a god was angry when the earth below their feet trembled and their houses were rocked by earthquakes. Now we know that earthquakes are the result of certain natural causes.

Earthquakes are sudden movements in the earth's crust. These movements may be due to several causes. Some are the result of great volcanic eruptions. The most dangerous

The text tells what happened to this barn

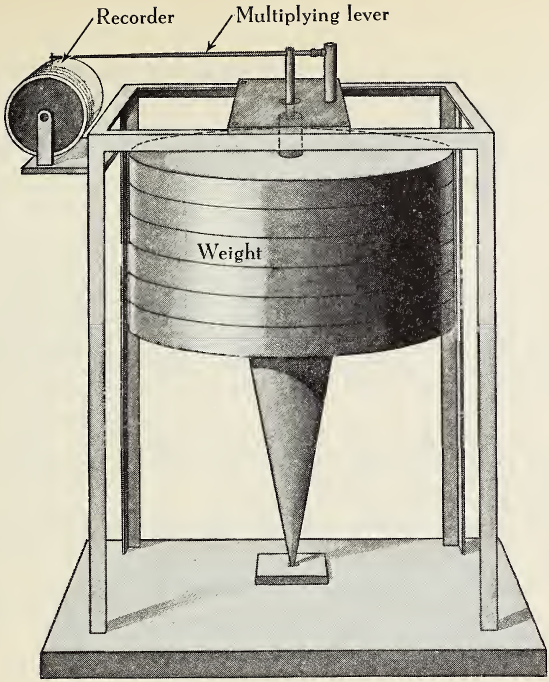
United States Geological Survey

earthquakes, however, occur when rocks in the earth's crust break or slip. As the crust of the earth becomes folded and wrinkled, the strain at times suddenly becomes so great that the layers snap. Then one layer slips past, or folds, over another. The slipping of the rocks may be only a few inches or several feet; but any of these sudden breaks causes a vibration, or trembling, of the earth, which we call an earthquake.

The slipping of the rocks may be up and down, with one block of the earth's crust rising and the one next to it falling. Or the layers of rock may slip past each other, moving in opposite directions. This happened at one time in California when the surface seemed to be cut into two parts. The blocks slid so far past each other that a road was moved about twenty feet. In another place the crack lay under a barn. As the two blocks slid past each other they twisted the barn and shed out of place, and tore down a fence.

This slipping of layers of rock in the earth's crust has taken place in the past and will probably do so in the future. People should prepare for earthquakes. If they will build earthquake-proof homes and public buildings, they will need to have less fear of earthquakes. Men have also learned to build sea walls that will keep out great waves resulting from earthquakes.

Men are working to learn more about the causes of earthquakes and how to prepare for them. An instrument called a seismograph has been in use for some time. It shows the direction of the earthquake and the force of the earth's vibrations. It also shows the length of time during which the vibrations occur. Recently a new kind of seismograph was made, which is much better than the earlier one. Many new ideas may come from further use of this new invention.



This is a seismograph

If you will notice the picture you can see how this instrument works. When the earth vibrates it causes the weight to vibrate. The weight moves the lever, which then makes little marks on the recorder. The recorder turns on its axis so that a long line of vibrations is made. Men can read these marks and tell how great the vibrations were, and how long they lasted.

Just as earthquakes can be explained, so other things can be explained. Men have done a great deal of studying to learn the causes of changes in nature. You have read about the causes of some of these changes which occur. In later

pages of the book you will read about the reasons for many other things which happen. There are many others that cannot yet be explained, but men are always searching for the true explanations.

THINGS TO THINK ABOUT

1. Long and narrow mountain chains have sometimes been formed by long folds, or wrinkles, in the surface of the earth. North and South America have long, high, and broad mountain ranges near their western coast and shorter, lower ranges near their eastern.

2. Some mountains are now being formed, while others are wearing away. How many things can you think of which cause mountains or soil to be worn away?

3. Earthquakes usually occur at places where the earth's crust is weakest. Why?

4. The bottoms of seas have at times become the tops of mountains, and mountains have sunk into the seas or have been carried there little by little.

THINGS TO DO

1. Learn where some great earthquakes have occurred.

2. Locate these places on the maps on which you located the volcanoes. Do they occur near regions of volcanic action? What would that seem to show about volcanoes and earthquakes?

3. If it is possible, take a trip to see a seismograph and one of the records. A seismograph records vibrations most of which are too weak to be felt by men.

4. Look at mountains, hillsides, and cuts through them. Find places which show where layers of the earth have been folded. What changes do you find which have taken place in the surface of the earth at these places?

5. When you are on the top or side of a hill or mountain, see if you can find traces of animals which lived only in the seas or oceans. Tell how they happen to be so far away from seas and oceans. What changes took place there?

IV

Men Learn from Rocks

SOME ROCKS WERE BROKEN AND CHANGED TO SOIL

ROCKS ARE MADE OF MINERALS

AS SOME ROCKS WERE WORN DOWN, OTHER ROCKS WERE FORMED

HOW FOSSILS ARE FORMED

YOU have learned how the earth may have been formed. You know that at some time an atmosphere was formed, and so a blanket of air covered the earth. Rain fell and water collected to make oceans. But the winds blew and the rain fell upon a cold, lifeless, rocky earth. Rocks, nothing but rocks, were everywhere. There was not a tree, flower, or blade of grass anywhere. There was not an insect, bird, or mammal. There was not yet one sign of life.

Do you know of any plants living today which grow on bare rocks? You may be able to find a few. But the greatest number of plants you know grow in soil. If you dig around a plant, you may find a great deal of soil. Sometimes the soil is many feet thick above any layer of rock. Soil has been most important to plants during the earth's history.

But where did the soil come from? To understand how soil was formed from the rocks which covered the land surface of the earth during the early part of her history is not easy. However, by studying the changes which are taking place in rocks today men have learned about many changes which have taken place in the rocks and surface of the earth in the past. They have learned of what rocks are made, how they have been made, and how they have been changed into soil.

By studying about animals and plants which were changed to rock, somewhat like the stone trees in the Petrified Forest of Arizona, shown in the picture on pages 86 and 87, men have learned about the life which grew upon the soil after it was formed.

Some Rocks Were Broken and Changed to Soil

Ever since the earth began to be the earth, its surface has been changing. Sun, air, water, and gravity have caused many of these changes. They have moved hills and worn down mountains. They have broken rocks into bits. And from these small pieces of rock they have helped to make the tons of soil you see about you.

Let us see how sun, air, water, and gravity work. Try to find an old monument, or a very old stone or brick building. Can you see where it is worn? Sometimes you can find a tombstone that is very old and worn in an old cemetery. The words on the tombstone may have become dim in all the years it has stood there in the sun, wind, and rain. If you know how old the building or tombstone is, you will realize how long it took to wear the brick or stone just a little bit. How long do you think it must have taken to change rocks into all the millions of tons of soil about you?

The sun, air, and water are acting everywhere about you, but too slowly for you to notice any great changes in a short time. But in the long period of the earth's history they have made very great changes upon the earth.

In ages long ago, just as today, the heat from the sun caused the outside of rocks to become hot in the daytime. At night the rocks cooled. In some places, as on the tops of mountains, this change in temperature from day to night was very great. It caused the outside of the rocks to expand, or become larger, in the daytime and to shrink at night. This expanding and shrinking continued until after a while it caused the outside of the rocks to crack and break. The out-

side of some rocks peeled off in thin layers like the peel of an orange. The surface of other rocks cracked and broke off, leaving sharp jagged edges.

Water also did its part in the breaking of rocks. You already know that water expands as it freezes. Have you seen water break a glass tumbler or a bottle when it froze solid in it? The same thing happened to many of the rocks. Most rocks had tiny cracks or holes in them. Often water got into the little cracks and froze there. As it did, it expanded and caused the crack or hole to become a tiny bit larger. Year after year as the opening became larger, more and more water got in. As it froze, it made the hole still larger. This continued until part of the rock was broken off. Such action of water on rocks was very slow, but in time it broke down a great many of them.

This shows a peak of a mountain in Switzerland before it collapsed

This shows how the same mountain looked after the top suddenly collapsed, due to the action of the weather through a great many year

Sometimes pieces of rock at the top of a mountain broke off and gravity caused them to drop down the side of the mountain. When the rocks went crashing down, they chipped other rocks as they bounced from one to another on their way to the valley below.

The winds also helped to break up the rocks. They blew sand and soil, already formed, against the rocks. These sharp-cornered bits of sand cut the rocks and wore them away.

Air sometimes changed the substances of which the rocks were made. As you know, air is made up of several gases. These gases entered the tiny openings in the rocks and made certain changes in the rocks themselves.

Perhaps you have seen changes in a piece of iron that was left out of doors. The moisture and oxygen of the air caused it to rust, unless some kind of paint prevented moisture and air from reaching it. In much the same way, oxygen affects iron and other substances in rocks. Sometimes soils are red, yellow, or brown because of the action of oxygen upon the rocks from which it was made.

Carbon dioxide in the air also helped in making soils. It was often dissolved in water and acted upon the rocks over which the water passed. Pure water could not dissolve rocks so easily. But when carbon dioxide was added to the water, it dissolved some rocks much more quickly. When this water passed over limestone, it dissolved the lime. When it passed through sandstone, it dissolved the lime which held the little bits of sand together. That freed the tiny pieces of sand and helped to make sandy soil.

Streams of water did a great deal to form soil. They carried small pebbles and sand with them. In some of the larger and swifter rivers even large rocks, or boulders, were carried along. As these pebbles and rocks were moved by the rushing water, they scraped bits off other rocks by bumping into them. They also rubbed against the banks and bottoms of the streams and rivers and wore them away. For hundreds of years some of the rivers continued to flow in nearly the same paths. Little by little they wore away the rock until sometimes deep canyons were formed, with the rivers flowing at the bottom.

You can see in the picture on page 93 how waves of water along the seashore dashed against the rocks day by day and slowly wore away part of them. In times of storms great waves splashed against the shores, and their extra force made the usual action of the water greater.

Glaciers too have helped to change the earth's surface. They have worn down mountains and dug out valleys in many parts of the earth. These great sheets of ice gathered rock and soil from mountainsides and bottoms of valleys. Then as they moved slowly over the country, the rock and soil which they carried along acted as great sheets of sand-paper. The weight of the glaciers pressed upon the rocks and soil beneath and wore off the land. Deep scratches that have been made by glaciers are found on rocks. Huge U-shaped valleys have been dug out by them.

In Alaska, Norway, and Chile there are many beautiful places where arms of the sea reach into the inland. They are called fiords, and many are probably valleys that were dug out by glaciers and then covered by the seas or oceans.

And so this is how the rocks were first broken up and soil was formed by the action of the sun, air, and water during millions and millions of years. It took years and years for the sun, wind, and water to crumble the rocks until quantities of sand, clay, and other sediments were formed. And during more and more years the rivers and streams carried this sand, clay, and mud and poured them into lakes and oceans.

You must not think that the sun, wind, and water stopped this action on the rocks just as soon as they had a certain amount of work done. They have continued that action all through the long ages of the story of the earth, and they are still at work. Rocks that you see today cannot stay as they are; they too, at some time, will be crumbled. But the action is slow, and it will take many, many centuries to change them a great deal.

You will read about how after many, many years, life may have started on the earth and later have begun to live in the

Roberts

Notice how the rock is worn away more at the bottom than at the top. In this way waves have worn away many rocks

A fiord in Norway

Read about how it probably was made

Galloway

soil. When plants and animals began to live in and on the soil, they too helped to change rocks and to make more soil.

Plants help to break up rocks in several ways. Roots grow into cracks of rocks, sometimes as far as several feet. The roots of plants dissolve certain substances from the rock. They also push pieces of rock apart. Tiny seeds become lodged in cracks. Then a little soil may drift into the crack. The seed grows and may at last become a tree or shrub. As it grows, the rock is spread farther apart or may fall entirely apart.

Animals living underground, such as earthworms, gophers, and ants, also help to change soil. Some of them bring soil up from underneath and leave it on the top. There it is open to the action of sun, water, and air. Other animals, especially those with hoofs, tramp on the ground and help to break rocks.

THINGS TO THINK ABOUT

1. Have you ever felt sand blowing against your face? Then you can understand how it could help to wear away rocks.

2. Old stone and brick buildings today sometimes show the effect of wind-blown sand. This is especially true in lands where there are dust storms. A severe dust storm acts like a sanding machine that is used to clean buildings. Such a machine wears away as much brick or stone in a few hours as the wind and sand usually wear away in many, many years.

3. You will learn later that men have not lived on the earth a very long time, considering how old the earth is. Can you explain how this is so?

4. Can you tell why it is thought that there is little or no erosion, that is, wearing down of rock and soil, on the moon?

5. Why do people notice so few changes on the earth during their lives, even though they may live to be quite old?

THINGS TO DO

1. Find several places where the sun, air, or water have caused rocks to break up into soil. Talk with someone who has known those places for a long time. Can you find out how long it has taken any noticeable change to take place?

2. Notice rivers or streams after a heavy rain. They are ever so much muddier than at other times. Sediment which they have washed from soil in their valleys causes this muddy appearance. These changes are taking place all the time.

3. Notice a picture of the Grand Canyon in Arizona. How many centuries do you think it may have taken the force of moving water to form this canyon? to form other canyons you may know about?

4. Look at the top of a mountain or the picture of one. Do you notice the number of pieces of broken rock? Why are the tops of some mountains covered with broken rock? Why do you often find piles of rock at the base of a steep cliff?

5. Notice the different kinds of buildings around you. Which type shows the greatest effects of weather for its age? Notice new additions to houses of wood, stone, and brick built at the same time. Which first shows the effects of the rain, sun, and air?

6. Why do people paint houses? To answer this look at a building that has never been painted.

7. Place a small bottle of water in the freezing drawer of an electric or gas refrigerator. Examine the bottle after the water in it has frozen.

8. Read about earthworms, to learn how they help to make soil.

9. Some very tiny living things called bacteria help to change rocks and soil.

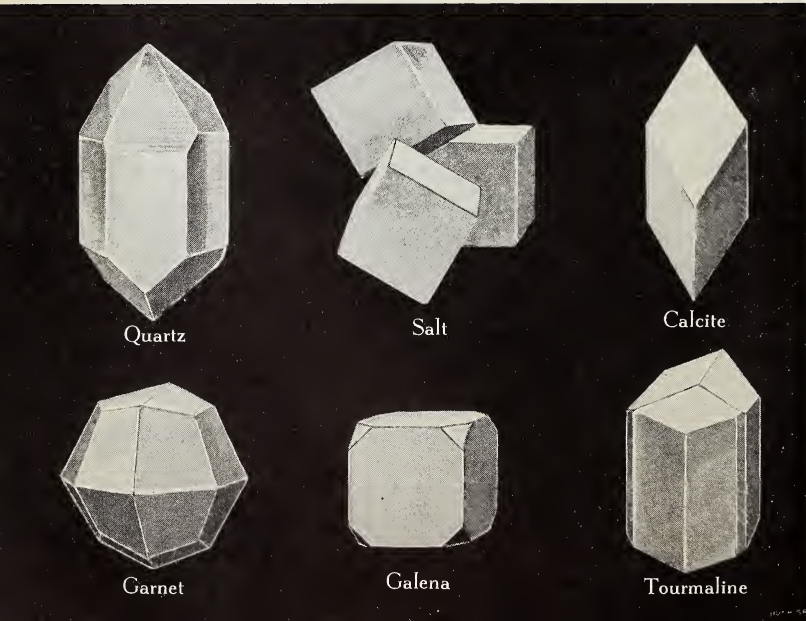
Rocks Are Made of Minerals

Pick up a piece of rock and examine it. Does all of it look the same? Can you find little grains in it? Are they all the same color? If you have a magnifying or reading glass, look at the rock and see how many things you can discover about it. How many things should you like to know about it?

Some rocks are dark, others are light; some have many different colors. That is because rocks are made of different substances called minerals. Many of the metals which you know, such as gold, iron, copper, and silver, are minerals. A mineral looks the same all the way through.

There are many different kinds of minerals in the rocks in the earth. Can you find different minerals in the rock you

These are some of the most common shapes of rock crystals



are examining? A few rocks are made of only one mineral. Each of these rocks looks the same all the way through. Other rocks contain several minerals. That is the reason why some rocks have little patches of different colors in them. Can you find different minerals in the rock which you picked up?

Sometimes the pieces of minerals in rocks have quite a definite shape; that is, the shape of each piece is about the same for one kind of mineral. Look at grains of salt under a magnifying glass. Notice the shape of each grain. Each grain is a crystal. You may be able to see crystals in the rock you are examining. Can you find any that look like those in the picture on page 98? Some may be several inches long; others may be so small that you cannot see them without a magnifying glass.

Crystals are not all the same shape. Notice the different shapes in the illustration. See how many shapes of crystals you can find. Each mineral forms its own shape of crystal.

There are many, many different kinds of rock. In some the minerals are in the shape of crystals. In others the minerals do not form crystals. You can probably find both kinds of rock.

You know that some metals are worth more than others. Some can be used in one way, some in another. Since men can tell what the different rocks are by their minerals, they know if a rock contains gold, silver, copper, or other valuable mineral deposits. They can determine if any ore is worth mining. For this reason it is very helpful for men to be able to tell which minerals are found in any rock.

One way in which men can know the different kinds of minerals is by their crystals. Other ways are by their color and by their hardness.

Look at a number of pieces of rock and minerals. Some minerals are quite soft. These can be scratched with a fingernail. Can you find any that you can scratch? Some are a little harder. They cannot be scratched with a fingernail, but they can be scratched with a penny. Other minerals are so hard that they cannot be scratched easily. The very hardest known mineral is the diamond. It will scratch all other known minerals.

Quartz is the most common mineral in the rocks at the earth's surface. When you look at sand, you are looking at quartz. Sand is mostly quartz that has been broken and ground by the action of water into small grains. Sometimes you can find quartz crystals in rocks which you see on hills or mountains. You can tell whether it is quartz by its shape, which is usually very much like the crystal shown in the illustration on page 98. Sometimes you find quartz that does not have a regular shape, because it was crowded for space when it cooled, and so it could not form a crystal.

If you rub quartz on most other minerals, it scratches them, because quartz is very hard. Mountains or rocks which contain great amounts of quartz are less apt to be worn easily than soft rocks are. Can you understand why?

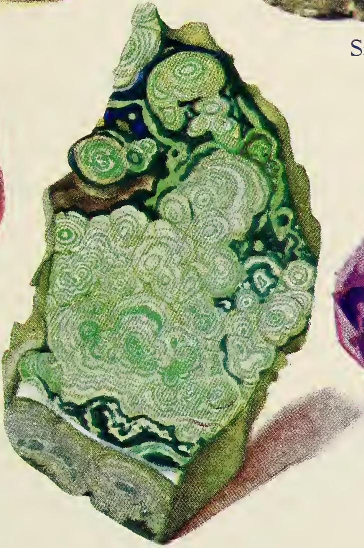
If you examine many different rocks, you will notice many colors in them. Some rocks are red, yellow, or different shades of brown. Others are blue, green, or gray. Some seem to be pure black. Many rocks contain several colors. These colors are caused by the minerals in the rocks. Sometimes grains of pure minerals are in them. At other times the color is there because some mineral was dissolved in the rocks when they were formed. See how many different colors you can find in rocks. Different minerals probably caused the different colors.

THE PICTURE FACING THIS PAGE IS FROM A PAINTING BY KATHARINE BURTON.

Mica

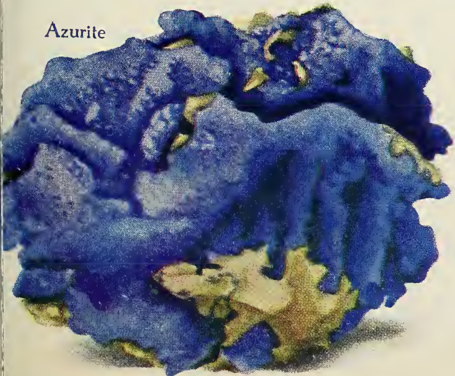
Smoky quartz

Rose quartz

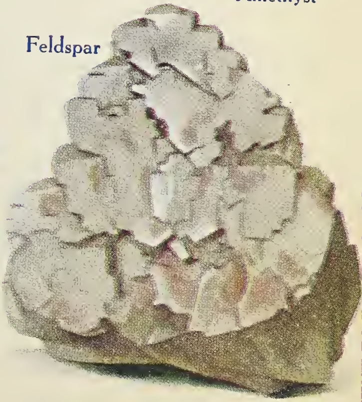


Malachite

Amethyst



Azurite



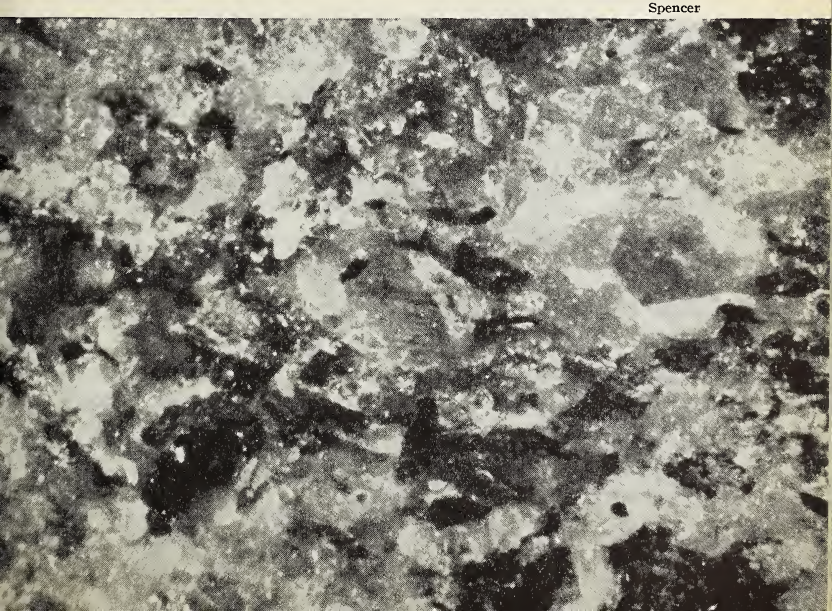
Feldspar

Pure quartz does not have a color. It is clear and looks like glass. Then it is often called crystal. But quartz may be found in many colors. In that case, when it was formed, other minerals were dissolved in it and colored it red, rose, yellow, purple, blue, or green. Each mineral caused it to have a certain color. Sometimes it has a dark color and is called smoky quartz. Such quartz is colored by two or more minerals.

Mica is another very common mineral. It is smooth and shiny. You have probably seen it in rocks. Small pieces of it are often found in rocks. It reflects the light and seems to sparkle. Sometimes large pieces of mica are found. Mica splits into very thin sheets or scales that may be bent a little. They are so clear that you can often see through them. There are two kinds of mica. One has a very light color, and the

This is the way granite looks under the microscope

Spencer



other is dark and smoke-colored. Mica is so soft that it may be scratched with your fingernail.

Granite is rock made of quartz, mica, and a third mineral. This third mineral is feldspar. It is not glassy like quartz, but has a pearly appearance. When it breaks, it does not have rough edges. It breaks with little flat surfaces, which shows that it too forms crystals. Feldspar is very hard, but not so hard as quartz. Sometimes there is a fourth mineral, which is very dark. It is called hornblende.

There are many other minerals. Some are ores of common metals, such as iron, copper, lead, and tin. Precious stones or gems are minerals or groups of minerals that are found in the earth and mined from it. Some of them are very beautiful, and some are very rare. Many minerals can be rather easily recognized. Others are much more difficult to recognize. Usually we must ask experts to tell us what they are.

THINGS TO THINK ABOUT

1. The thin covering over an electric fuse is made of mica. Since mica does not burn, it is useful in many places where it will be near fire. It is used on certain coal stoves, called base-burners, and in some kerosene stoves.

2. Candy gumdrops are in one way somewhat like quartz. The gumdrops are all the same kind of candy but colored differently. Many stones are quartz which has been colored with different dissolved minerals.

THINGS TO DO

1. Make a map of your state, province, or country. Draw in different-colored circles and squares, to show where the common minerals may be mined. Can you tell why they are often found in mountainous regions? Have many changes taken place in those regions?

As Some Rocks Were Worn Down, Other Rocks Were Formed

SOME ROCKS WERE MADE FROM SEDIMENT

Look at your yard at school or home. How much soil or other sediment do you see? When you drive into the country, notice the cuts in the hills along the highway. You may see black soil, sand, clay, large pebbles, or boulders all along the way. In some places, no matter in what direction you look, you see nothing but soil. You may look for miles and never see a boulder. Then again, in other places, you scarcely can see the soil for the rocks. It is like this over much of the surface of the earth.

However, great quantities of broken rocks and soil have been formed which did not remain as sediment. They were changed back into different kinds of rock. Often this change took place at the bottoms of shallow seas, where there was great pressure. Sometimes the sediment was washed in by rivers until it was several feet in thickness. As it collected and stayed in these places for years and years, it was slowly cemented together. The water which covered it or passed through it carried lime, which it deposited in the sediment. When the lime hardened, it held the clay or grains of sand or other sediment together and formed rocks.

Did you ever cover yourself or have someone else cover you with sand, as you were lying on the seashore or on a sand pile? Do you remember how heavy that small amount of sand was? You had to push part of it off with your hands before you could get up. How heavy would it have been if you had had several feet of sand over you?

Could you get up if you had several feet of sand over you?

Just imagine, then, how much weight must have been pressing down on layers of sand and mud at the bottoms of seas or shallow parts of oceans when they had hundreds of feet of sediment and water above them. The pressure was enormous, and the layers of sediment were pressed and cemented together. This pressure continued for ages and ages, until the sediment was changed into rock, called sedimentary rock.

At some later time, as the surface of the earth slowly sank in some places and rose in others, some of the layers of rock at the bottom of the seas were pushed up above the surface of the water. Some of them are the sedimentary rocks which can often be seen on hills and mountains.

There are several kinds of sedimentary rocks. The kinds depend upon the sediment from which they were formed. One kind is called sandstone. You can guess that it was formed by sand that piled into layers. Other kinds you will learn about are conglomerate, limestone, shale, and coal.

Feel of several pieces of rock. Can you find one that feels or looks sandy? Perhaps it is sandstone. Sandstone is very common. Sometimes it contains a small amount of lime that has helped to cement the grains of sand together, or it may have some clay, but most of it is sand. You can often tell whether you have a piece of sandstone by scratching it. The grains scratch off quite easily. Sandstone may be red, gray, brown, or yellow in color.

When pebbles or larger pieces of rock are cemented together by sand and a little lime, they form conglomerate rock. It is so called because *conglomerate* means "a mixture or heap of many kinds of things or parts closely packed together." If the pebbles or larger stones that formed conglomerate rock are smooth and nearly round, the rock is called pudding stone; the smooth and rounded stones are the "raisins" or "plums" of the pudding. The stones may be of any size from less than an inch to several feet in diameter. Sometimes when a stone is mostly sand with just a few pebbles in it, it is called a pebbled sandstone.

Shale is made from clay or silt. Therefore the sediment in shale is very fine. Shale often splits or scales off into layers or sheets. Sometimes, however, it breaks into blocks. Shale

Orne

The text tells how conglomerate rock was formed

is very soft and crumbles quite easily into small chips. It may be found in several colors of reds, oranges, and yellows. You can usually recognize shale by the chips into which it breaks. If you breathe on it, there is an earthy or clay odor.

The shells and bones of animals have a great amount of lime in them. It was this lime that helped to form some of the limestone in the earth. As the animals in the seas died, their shells and bones sank in the water. As more shells and bones were added each year, the layers at the bottom became thicker. Some lime had already been in the seas, but more was carried into them by streams, which had dissolved the

lime from rocks on the land. Part of this lime was added to the layers of shells on the floor of the seas or oceans. In much the same way that sandstone was formed, this gathering of lime was pressed into limestone.

Coal is another kind of sedimentary rock. It was formed by plants that grew in swamps and became covered with other sediment. Later you will read more about how coal was formed.

Limestone, sandstone, and other sedimentary rocks may contain fossils (see the picture on page 108). As the sand and lime were deposited in layers, bodies of animals and plants were often covered by them. Sediment forming on top prevented decay, and fossils were formed. Since sedi-

These boys have noticed that the shale is breaking into small layers

Wilson

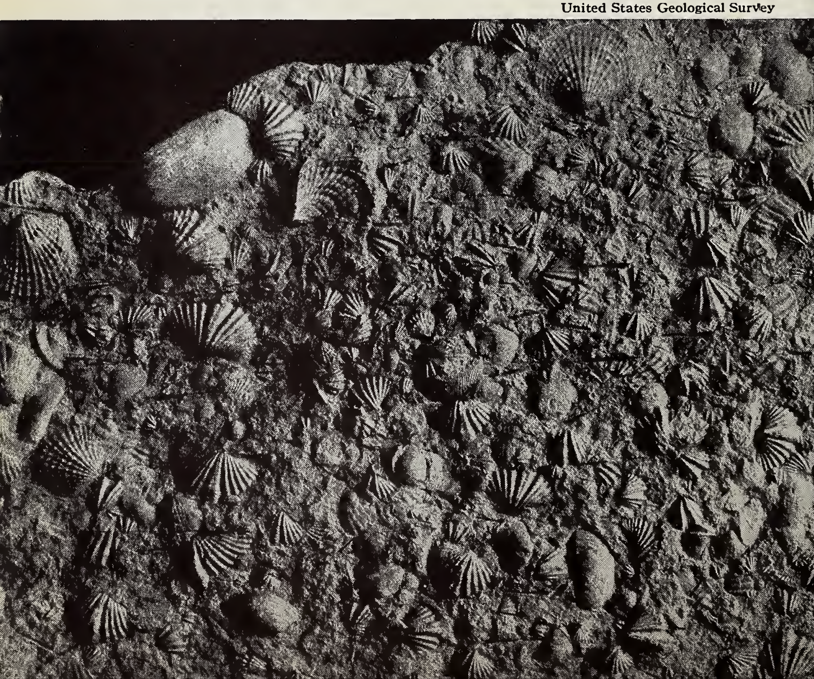
mentary rocks have not been heated or changed greatly, many of the fossils have been preserved. Finding fossils in rock is one way of determining whether a rock is sedimentary. If it has fossils, it is sedimentary.

SOME ROCKS WERE MADE BY HEAT

Some rocks, called igneous rocks, have been formed in another way. *Igneous*, which means "fire," is the name given to those rocks which were formed by heat. All the rocks that at one time have been melted and later cooled are of igneous beginning.

From fossils like these, men can learn about the animals which lived long ag

United States Geological Survey



The very oldest rocks of the earth are igneous rocks. They were the first rocks formed when the earth cooled. They were the first ones that were later changed into sediment by the action of the sun, air, and water.

You already know that some of the solid rocks and minerals below the surface of the earth have at times again become melted and formed pockets of hot rock. When these melted rocks have poured out upon the earth from volcanoes, they have cooled and formed igneous rocks. Sometimes they have cooled in some crack in the surface of the earth. Then they have formed another kind of igneous rocks.

Sometimes igneous rocks cool very rapidly. When they do so, they become glassy-looking. If they cool very slowly, they usually form crystals. Sometimes the crystals are quite large. At other times they are so small that you need a magnifying glass to see them. Examine a piece of rock to see if it has crystals. If it has crystals, it is probably an igneous rock.

Granite is one of the igneous rocks which have crystals. It is composed of quartz, feldspar, and mica. It is such a hard rock that it takes years and years for the wind, sun, and water to change it a great deal. For this reason it is used for buildings and for monuments.

SOME ROCKS WERE CHANGED BY HEAT AND PRESSURE

Rocks are just like everything else on earth. They are always changing. The change may occur very slowly, but it is always taking place. As you have learned, some rocks are broken and changed to sediment. This sediment may again form rocks, called sedimentary rocks. You have just been

United States Geological Survey

Melted rock which once filled two long cracks in this mountain cooled into very hard rock. The softer rock on either side has been worn away slowly, leaving the cold lava rock

reading about other rocks that are formed by heat. But each of these two kinds of rock, sedimentary and igneous, may again be changed into a third kind. This is called metamorphic rock, which means "changed rock." We shall now see how metamorphic rock came to be formed.

Take some loose sheets of paper. Put your hands on opposite edges and press the paper toward the center. In this way you can make ridges in it. Imagine that the sheets of

paper are layers of soil and rocks, and that each layer is many feet thick. As you bend the sheets, see if you can make hills and valleys. It was in this way that pressure pushed some layers of the earth up and forced others down. Of course, it took many, many times as much force to bend the layers of rocks as it took you to bend the paper.

Some of the layers were forced to a great depth. They had tons of pressure above them and often very high temperatures below them. It was this very great pressure and heat that pressed and baked the sedimentary rocks into other kinds of rocks.

Sometimes hot lava poured out on, or pushed up through, layers of sedimentary rock. The heat was so great that parts of the layers of sedimentary rock were baked and changed into metamorphic rock. Notice the illustration to learn what happened to the hot lava.

Some layers of limestone that had been formed in part from the lime of shells and bones of animals were also changed by pressure and heat. This limestone was changed into marble. Limestone and marble are made of the same things. Marble is merely changed limestone.

One of the most common metamorphic rocks is gneiss. It is made of the same minerals of which granite is composed. In gneiss these minerals form streaks or layers in the rock; in granite the minerals are scattered throughout the rock. Compare pieces or pictures of gneiss and granite. Pieces of gneiss range from dark to light in color, depending upon the minerals which make up the rock.

Pebbles which are found along the seashore are usually made of a rock called quartzite. It was made when sandstone was changed by heat and pressure. Quartzite usually is very hard, and may be white, tan, or pinkish in color.

Mica schist is a very common rock which has been formed by heat and pressure. It is made mostly of quartz and mica. The mica found may be either the light or the dark kind. Schist is quite easily recognized by the many small pieces of mica in it and by the fact that it seems to be formed of layers.

Of course you know slate when you see it, and you know how it is used. Do you know how it was made? It also is a metamorphic rock. Slates are usually made from shales, or layers of clay or mud which have been changed and pressed into rock.

Many, many layers of sedimentary and igneous rocks have been changed into layers of metamorphic rock. But this action does not stop. Just as some rocks are being worn down and others are being made, so still others are being changed into metamorphic rocks.

THINGS TO THINK ABOUT

1. The following table shows what kinds of rocks are formed from different kinds of sediment:

Kind of Sediment	*Sedimentary Rocks Which Were Formed*	*Metamorphic Rocks*
1. Sand	Sandstone	Quartzite
2. Gravel	Conglomerate	Gneiss or different schists
3. Clay, mud, and silt .	Shale	Slate or different schists
4. Shells and other lime deposits	Limestone	Marble or different schists

2. Perhaps you would like to know how much pressure there is on layers of sediment. Scientists know how heavy some sediment is. They say that some sediment covering one square inch of surface and standing one foot high weighs a pound. If you had 200 feet of sediment above this one square inch, you would have

200 pounds of pressure on just one square inch of surface. How much pressure would there be on one square foot of surface? How much would there be if the sediment above were 2000 feet thick?

THINGS TO DO

1. Notice any layers of rock that may be cropping out, or coming out of, the side of a hill near your home. Tell how they were made.

2. Visit a quarry, or a place where monuments are cut. Which rocks are the hardest to cut? Harder rocks last longer than softer kinds.

How Fossils Are Formed

Scientists know the size and shapes of plants and animals which they have never seen alive. They know the kinds of food the animals ate, how they were protected, where they lived, and many other things about them. Yet these plants and animals have never been seen by any man. Their kinds have not lived upon the earth for thousands of years.

If scientists have never seen these living things, how do you think they can know so much about them? Scientists have learned much about them from prints or molds which were made of the plants and animals. Of course, the prints were not made as you would take a picture with a camera. They were made by forces in nature. Often a piece of stone is found which resembles the likeness of an animal molded in clay or carved in stone. But men did not do the molding. Such prints and molds are fossils.

Fossils may be not only the prints of plants and animals, or molds showing the shape and size of the living things which made them; they may also be plants and animals which have been entirely turned to stone. Scientists have also learned much from this kind of fossil.

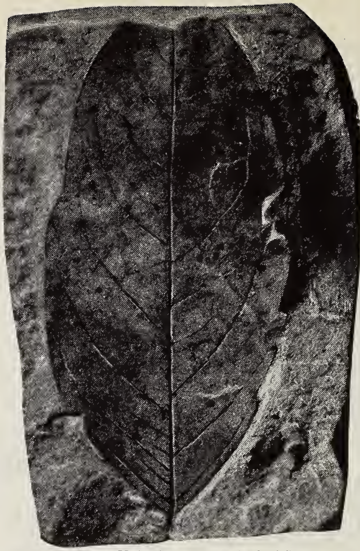
Each kind of fossil was made in a different way. When you step in mud, you leave a footprint. The print dries and becomes hard. Now, if that mud with your footprint in it could be preserved for many years, and the mud possibly turned to rock, it would be a fossil. People finding it thousands and thousands of years from now would be able to tell many things about you. They would know something of your size, how heavy you were, whether you walked on your toes or your whole foot, and whether you were walking or running. They would be able to learn things about you, just

Galloway

The bones which these men are digging in Utah will probably be fitted together to show what kind of animal died there long ago

as men in the picture are able to learn about the animals whose fossils they are digging.

Long ago animals stepped in the mud. Their tracks dried and became very hard. Sand or dust blew into them, and they became covered, sometimes beneath many feet of soil.



United States Geological Survey

Left. This is a fossil flower. *Right.* From this fossil leaf, men learn of one kind of tree that grew long ag

The tracks were protected, and the mud about them was changed to rock. These tracks are sometimes found when men are digging or working in the rock. The tracks have become fossils. They are pictures taken in mud.

In the same way leaves and other parts of plants fell upon the mud and left their prints, somewhat like those in the pictures. A great number of fossil leaves, branches, and cones of trees are found as prints, or pictures, in coal. Sometimes just the print of a shell remains in the rock. It looks as if someone had pressed a shell into soft earth and then carefully taken the shell away. That is almost what happened, only no one pressed the shell there. Mud and sand above it did the pressing.

Long ago animals died, just as today. Their bodies usually were attacked and eaten by other animals. If they were not eaten, bacteria soon caused them to decay. Water and the oxygen of the air also helped to cause their decay. In this way most of them were soon destroyed. Little was left of their form.

But in one way or another the bodies of a few animals were protected from decay. Of those that died on the prairies some, once in a great while, were covered quickly by sand blowing and piling up over their bodies during severe sandstorms. Some animals that went to rivers for water were caught in quicksand. Some were caught in floods and quickly covered by water and sediment. At other times live animals were suddenly buried by great landslides, when soil slid down hills or mountains, or by lava, dust, and ashes from volcanoes. In all these cases there was very little or no chance of decay, and often the bodies were later changed to fossils.

Sometimes fossils were formed in such a way that men have been able to cut through the fossils and see what the inside of the plants or animals was like. They have made slides for the microscope which enabled them to see what the cells were like in the original living things.

Some fossils have been discovered in places where the soil is now always frozen. Explorers in the Far North have found animals which were frozen in the snow and ice. These animals had remained there, frozen, through thousands of years. Some of them were still covered with hair when they were found. Their flesh was so well preserved by the cold that it was eaten by the dogs. These fossils are the best for study, for they show almost exactly what the animals were like.

Would it not seem strange to see a log of a tree that had no wood in it? That is what you can see in parts of Arizona.

There is one place where great trunks of trees are lying on the ground, but there is no wood to be found anywhere. The trees have turned to stone. Beautifully colored minerals have taken the place of the wood. We say such trees have become petrified.

Petrified wood can be found in a number of places, but seldom is it found as it is in the Petrified Forest in Arizona. This forest is not standing. Great stone trees lie scattered on the ground. They have been there for many centuries. They are fossils of trees which lived long ago.

No trees exactly like those that have been found petrified are living today. But by studying the logs of stone, scientists have been able to learn what trees living now are near relatives of those that lived so long ago.

Suppose that rocks of every age contained a fossil of every living thing of that age. Then, if these rocks were piled up in the right order, the entire history of the earth could be read. But rocks have not been formed in this way. There is probably no layer of rocks which contains a fossil of every kind of thing that lived when the rock was formed. Nor were rocks of all ages formed one upon another at any one place. Conditions were not always suitable for rock-building. Some layers were built and washed away. Fossils in some layers either never were made or were destroyed. Therefore the story of the earth is not complete. But men have found many fossils and through them have learned a great deal about the early life upon the earth.

THINGS TO THINK ABOUT

1. Fossils are found usually only in sedimentary rock. Why should you not expect to find them in igneous and metamorphic rock?

2. In some fossils of shells there is nothing left except the print of the shell. What has happened to the shell?

3. Footprints are sometimes found in cement in sidewalks. These were made when the cement was soft, and hardened in the cement. This shows in a more rapid way how some fossils may have been made.

THINGS TO DO

1. What kinds of fossils can you find near where you are living?

2. Try to find a fossil in a piece of coal.

3. Make a print of a leaf in plaster of Paris to show how a fossil may have been made in mud. Plaster of Paris is a powder that hardens and forms a white solid mass after water is added to it. It often may be purchased at lumberyards or at drugstores.

V

Early Life

THE BEGINNING OF LIFE UPON THE EARTH

LIFE STAYED UPON THE EARTH

THE AGE OF FISHES

THE COAL AGE

FOR millions of years the sun, air, and water had been wearing away and changing the rocks on the surface of the earth. Volcanoes had poured hot rock out upon the surface and had spouted gases and dust into the atmosphere. Mountains had been pushed up, only to be worn down again. Continents had risen in some places and had sunk in others. But rains fell and winds blew upon an earth that had no living thing upon it. There were only the bare rocks and lifeless seas and oceans.

Had you sat by an ocean when the earth was less than one third as old as it is now, you would have been alone. Clouds could have floated past, ocean waves could have broken along the shore; but you would have been unable to see any living thing except yourself.

It was very different from what it is now. The earth now is covered with living things: some living things very, very large, such as tall trees and large animals; and other things so small that they cannot be seen even with the strongest microscope. There have been many, many changes during the hundreds of millions of years since the earth was lifeless.

The ocean then would have looked very different from the picture, which shows many kinds of things that live in the oceans now. As you read the text you will learn how these jellyfishes, sponges, corals, sea anemones, and many other living things, may have begun to live upon the earth and to make it what it is.

THE PICTURE FACING PAGE 120 IS FROM A PAINTING BY ELSE BOSTELMANN.

The Beginning of Life upon the Earth

At some time in the very early ages, life started upon the earth. Just how old the earth was when life began, we do not know. It was probably sometime after the atmosphere and oceans had formed. It may have been after some of the rocks had been worn and changed to soil. But there have been so many changes on the earth since life began, that it must have been when the earth was still quite young.

No one knows just how life started. It is one of the many things that are not known at the present time. It is thought by many scientists that life first began in shallow water, perhaps in a quiet pool or shallow sea. There, as the waves washed against the rocks, tiny bits of life may have been washed back and forth in the water.

There are some reasons for thinking that these first things which lived upon the earth were more like plants than animals. Perhaps in some tide pool or sea or quiet shallow part of the ocean a little plant started to live. It may have had only one cell, and it may have been so tiny that it could not have been seen with the eye alone.

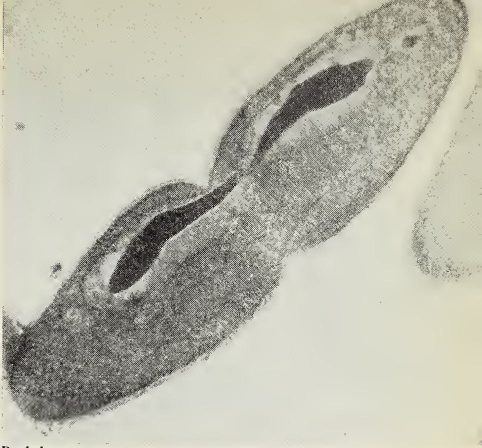
The first tiny living things may have looked like these one-celled plants, seen through a microscope

Buchsbaum

Many things are known about plants that have just one cell, because such plants are living today. There are great numbers of them. They are everywhere; in

the air, in the soil, and in the water. They are on everything you touch, all around you.

But you cannot see them without a microscope. Some are so small that thousands of them could be on the head of a pin. Others are so small that as yet the separate plants have never been seen, even with the most powerful microscope.

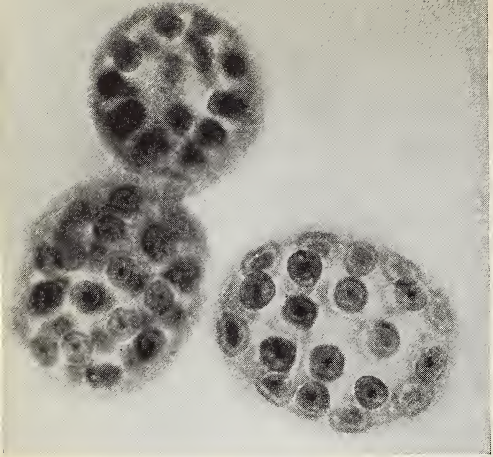


Buchsbaum

This picture, taken through a microscope, shows a one-celled animal which is dividing

In order to live, those tiny plants living long ago probably had to take in air, water, and other substances, just as their kinds do now. When one of these tiny plants living today takes in these things, it grows larger and larger. Finally, it may become so large that it divides into two parts. It becomes two cells, or plants, instead of one. Often these little plants separate. Then after a while each of these two grows and divides into parts, and there are four cells, or plants, as is shown in the picture on page 122. If the first plants on the earth grew as their kinds do now, they too took in air, water, and other substances, and then divided to form more plants.

These tiny plants of long ago may have lived in one little pool until they had divided and formed millions and millions of other tiny plants like themselves. Perhaps some of them were washed over into another pool. Or other little plants may have started in other pools just as the first ones had started.



Buchsbaum

This shows how cells are sometimes held together, and live as a group

But these tiny one-celled plants did not continue to be the only kind of living things in the pools. At some time other kinds of tiny cells began to live. Just how they started, no one knows. Perhaps one kind of little cell was formed that was not like the others. It may have been so different that it could not make its own food. In that case it was in danger of starving. Then this cell may have succeeded in living only by using one-celled plants near it as food.

If this little cell lived upon other cells, it may have been more like an animal than a plant. Perhaps it became the first animal that ever lived. As it divided, the two new cells may have been quite like the parent. Maybe they too lived on plant cells. That is how it may have been that animals first began to live on the earth.

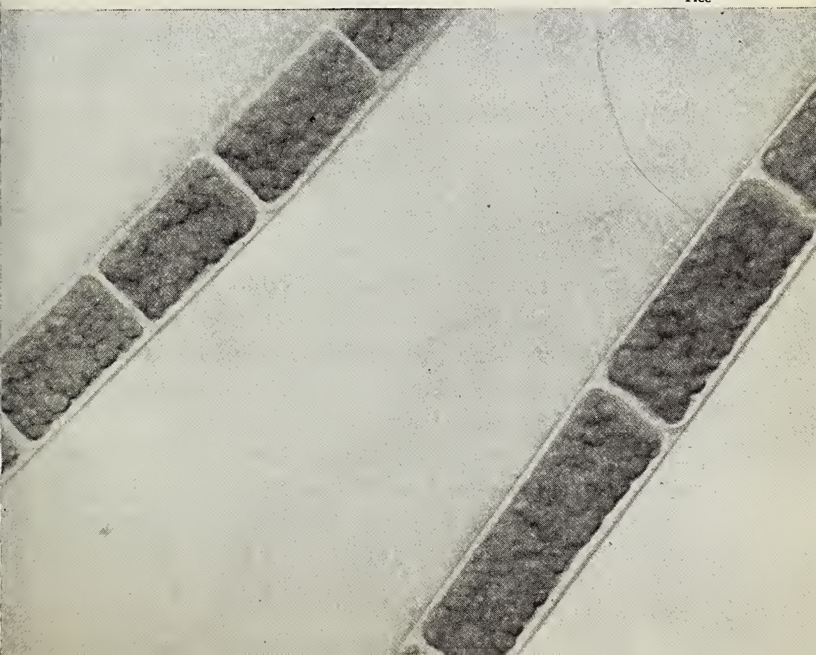
These tiny plants and animals may have continued to live and grow and divide until there were many, many small living things. But some did not always behave like their parents. We do not know how, but it is thought that in some way some of them began living in groups. Some of the plant cells may have formed one group which was held together by a kind of sticky substance, as those shown in the picture on this page. Perhaps some of the animal cells formed another group.

At first these groups of cells may have just lived together, each cell taking in its own food and air and doing its own growing and dividing. But after a while perhaps the duties were divided. Perhaps some cells could take in air better than others, and they neglected to take in food. Some other cells may have been better in gathering food. They could take in food and let other cells digest it. Little by little they may have begun to act as if they were one living thing instead of many.

Have you ever noticed a quiet pool of water that looked green? It looked green because it was filled with tiny green plants. Some of these plants are often one-celled. Others have many cells. Sometimes the cells are fastened end to

Sometimes many plant cells live together to form one long string of cells. Those below are called algae

Tice



Tice

These little bells are tiny one-celled animals which cannot be seen with the ey
alone. Each animal has a spring-like stalk by which it is fastened to somethin
in the water. They are so soft and small that they are easily destroyed

end until they look like tiny threads in the water. If you will put some water from a quiet pool on a slide for your microscope, you can usually see several kinds of these plants. They are called algae. The algae which are shown in the picture on page 125 may be similar to those that may have begun to live together long ago.

It is not easy to read the chapters in the earth's history that deal with the first life. The first plants and animals were so small and soft that little seems to be left of them in

the rocks. But it is thought that from the beginning many tiny plants and animals have lived and produced others much as their kinds living now do.

Many, many years later new kinds of living things started to live upon the earth. One of these early kinds of animals was the sponge. The first sponges were very much like those that live now. You have seen sponges which are used to wash automobiles and blackboards, or are used in the bathroom. These sponges are the skeletons of animals. The animals that lived in them had jelly-like bodies that lived in the holes and all through the skeleton. Like those living today, the first sponges had many cells. Some cells did one kind of work, while some did another. Some cells took in the food and water which were used by other cells.

When they are growing, the sponges of today usually have the shape of a ball or cone or glove. Many sponges are colored different shades of red, yellow, or brown, while others are green, violet, or black. The green ones probably have green plants in them that give them that color. Some sponges are as large as two or three feet across and a foot thick. Others are very small, about the size of a drop of water. Usually they live in salt water, but a few live in fresh water. They live fastened to rocks or other objects at the bottom of the water. The first sponges that lived long ago may have been like some of these which we know today.

Since the first plants and animals probably had only one cell, that cell had to do all the work. Because of this people say that plants and animals with only one cell are a low kind of plant or animal. Higher plants and animals are those which have many cells. The highest plants have roots, stems, and seeds. The highest animals have lungs, a heart, and other organs of the body.

Fenimore Johnson Laboratories

The coral which you may have seen is made up
of the skeletons of coral polyps like the

Since the sponge has many cells which have different kinds of work to do, it is a little higher than the one-celled animal. But since it does not have a real mouth, stomach, or lungs to eat and breathe with, it is not a very high kind.

Not very far from the sponges in those ancient seas other very interesting-looking animals began to grow. They were similar to some which live today in tide pools along the sea-coast. When you see them waving in the water they remind you of flowers. They reminded the man who named them of flowers. He called them sea anemones, or sea flowers. When many of them grow close together, they are a garden of sea "flowers," all animals, of many lovely colors.

They have long beautifully colored arms. These arms are made of muscle with no bones, but they are very dangerous. With them one of these animals seizes and stings its prey, another animal which it uses as food. These arms then carry the food to the mouth and into a kind of stomach which is much like a bag. When danger is near, anemones can draw in their arms and close up into a kind of round mass. Then again, they can open and stretch out their arms like petals of a flower. Notice the anemones in the illustration facing page 120.

Sea anemones have relatives which are called coral polyps. They are very tiny animals, only a fraction of an inch long. Some live alone or in small colonies, but others live together by the millions. They use a kind of lime from the ocean water to make their skeletons, which you know as coral, and which may be seen in the illustrations on pages 128 and 130.

The skeletons of millions and millions of coral animals which grow together form what are known as coral reefs. There are several very large reefs. One near Australia is over a thousand miles long. Just think how many coral polyps must have lived to make so large an amount of coral. Their

Fenimore Johnson Laboratories

Several kinds of coral are shown on this ocean floor

ancestors, or early relatives, have lived through many, many millions of years.

Another of the early kinds of animals was the jellyfish. This animal was very much like the jellyfishes which boys and girls today see along the seashores when the waves wash them in. Jellyfishes are not fishes at all. They are soft and have no shell. They are mostly water. Their bodies are too soft to leave many prints in the rocks. For this reason, remains of those which lived millions of years ago are not often

found. However, a number of fossils of jellyfishes have been found in Alabama and Vermont.

The moon jelly which lives along the eastern coast of the United States from Maine to Florida is a common kind living today. The part of the one kind of jellyfishes that floats on or near the surface of the water has the shape of an opened umbrella. From the lower side hang several armlike objects. They are fastened around the mouth, which is just a hole in the center underneath the umbrella-shaped mass. Jellyfishes of long ago may have been quite similar to those of today.

THINGS TO DO

1. If one cell divides into two cells, two into four, and four into eight, how many divisions will produce over 1000 cells? Suppose each division, under favorable conditions, took one hour. How many hours would pass before 1000 cells were formed?

2. If you have a microscope, place a very small piece of yeast in a glass of sweetened water that is just a little warm. Examine a drop every hour under a microscope. Do you see any buds? Yeast, coral, and sponges produce their young by forming buds.

3. Help your class to make a picture story of life on the earth. If your room is large enough, measure off 100 feet of heavy cord, colored, if you can get it. Fasten one end at a corner of the room and mark this the beginning of the earth. Measure off 30 feet. You may want to make a little card and hang it on the string at this point. If you want to use a big name, you may write on the card "End of Archeozoic (Beginning Life) Era."

Very little is known about the life of this age, but it is thought that the first one-celled plant began to live in an Archeozoic sea. Great mountains were formed at the end of this time.

You might draw pictures to hang upon your time line to show what was happening during the first age that your line covers.

Now measure off 25 feet more. At this point hang a card saying "End of Proterozoic (Early Life) Era."

During this time there were probably many one-celled plants

and animals. It is thought that algae, sponges, worms, the first jellyfishes, and corals had begun to grow then, too.

During this time many rocks were being broken up into soil, mountaintops were being carried to the sea, and other changes on the earth's surface were taking place as they have ever since.

The climate changed several times during this era. Glaciers appeared twice. It is thought that glaciers appeared in Canada about the middle of the era, and in some places near the tropics at about the close of the era.

The Proterozoic era was the time when the greatest amount of iron ore was deposited. Great fields of iron were made around what is now Lake Superior, and in Brazil and Sweden.

Later in the book there will be information to help you to complete your picture story of the earth.

Life Stayed upon the Earth

AGE OF TRILOBITES

As time passed on during the early ages, the first plants and animals became numerous. Then some little animals that looked quite different from the others began to swim and dart about among the other living things in the sea. These animals had real heads, bodies, and legs. They had eyes for seeing and feelers for touching. These little animals were trilobites.

A trilobite had a covering over its body. This covering was quite hard on the back of the animal, but not so hard underneath. By this time animals were eating one another as well as plants for food. Every living thing needed some kind of protection, if it was to continue to live. Therefore the hard covering of the trilobites protected them and at first made it quite difficult for other animals to use them as food.

The smallest trilobites were about one third of an inch long. The very largest ones were about two feet in length. But only a very few of the large ones have been found. The greatest number probably were from one to six inches long.

These animals lived and grew, and then after millions of years became extinct; that is, their kind disappeared from the earth. But scientists have been able to learn many things about them. They know from the fossils that trilobites belong to the family of lobsters, shrimps, and other animals called crawfish. They know that trilobites grew in much the same way as crabs do now. A trilobite grew and grew, and when the tough skin became too small, it split and was shed. Then the trilobite grew another covering. Even after it was grown, it shed its covering once in a while.

Lobsters and shrimps are living relatives of the trilobites, which became extinct long a

Look at the pictures and compare the trilobites and their relatives. How are they alike? What differences do you see? How do they compare in size?

Trilobites lived in different parts of the seas, depending partly upon what kind of food they ate and how they caught the food. Some trilobites were very slow and not very active. They floated or swam lazily backward and forward, bottom or topside up, catching what food they could. Others were poor swimmers but had stout legs with which they walked on the soft bottom of the seas. They darted and plowed their way through the soft muddy bottoms in search of food.

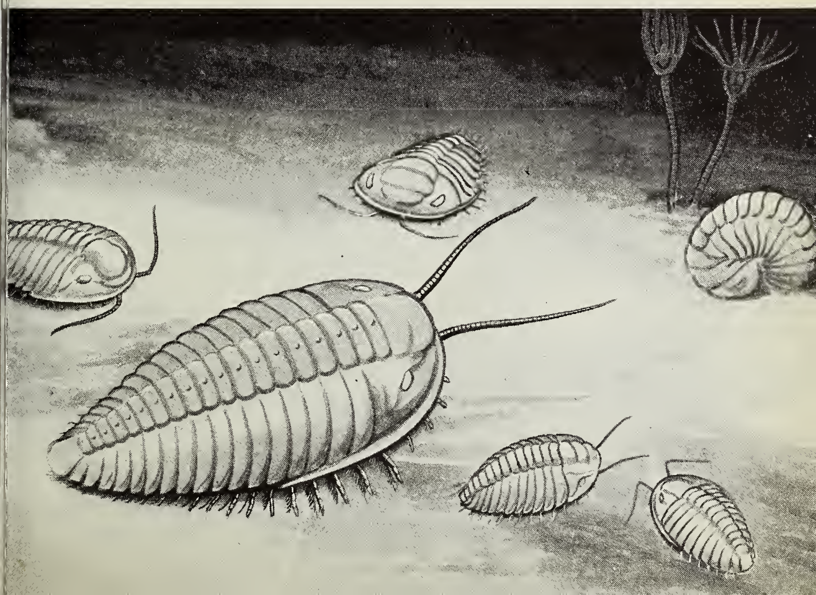
Some trilobites burrowed head first into the mud for the living food they could find there. Others buried themselves in the mud, backing in and keeping only their eyes sticking

up out of the mud. There they lay ready to seize any plant or animal that happened to be passing their way. Usually the trilobites were very flat. Their big eyes extended out from the top of their heads. This made it possible for them to lie almost completely hidden. Other trilobites were mud-eaters. They crawled about eating mud for what food they could find in it.

Trilobites lived and grew and produced their young for many, many centuries, until there were millions and millions of them. Scientists have called the time when they were most numerous, or when the largest number lived, the Age of Trilobites.

During all the millions of years that the trilobites lived in the seas, the numbers of other animals were increasing. These other animals became so numerous that they began

What habits may have helped the trilobites to live on the earth for a long time?



to need great quantities of food. Some of them fed upon plants. But many fed upon other animals. Some may have found ways of eating the trilobites in spite of their hard covering. They may have attacked the trilobites on the underside where the covering was not so tough and hard.

Before this time the trilobites had depended upon their tough top skin for protection. But this did not protect the soft parts underneath. Some kinds of them had the trick of rolling up in a ball. In this way the hard surface on top protected the soft part underneath. Perhaps this trick saved them for a while against the other animals, but finally they all died or were killed.

During the Age of Trilobites new kinds of plants and animals had begun to live in the seas. Many kinds which live today began to live then. One kind of new plant was a kind that lives in seas today and is called seaweed. Animals with shells, like the periwinkles, clams, and snails, were beginning to develop. Starfishes and many others had begun to live, also.

THE FIRST FISHLIKE ANIMAL

After life had started, millions and millions of years passed during which most of the living things of the world were small and belonged to the lowest kinds. The seas and oceans swarmed with one-celled plants and animals, and with sponges, corals, jellyfishes, trilobites, and animals with shells.

But have you noticed that not one animal as yet had a backbone or a bone of any kind? Either they had no hard parts to their bodies at all, as the jellyfish, or they simply had a hard covering or shell, as the trilobite or shellfish.

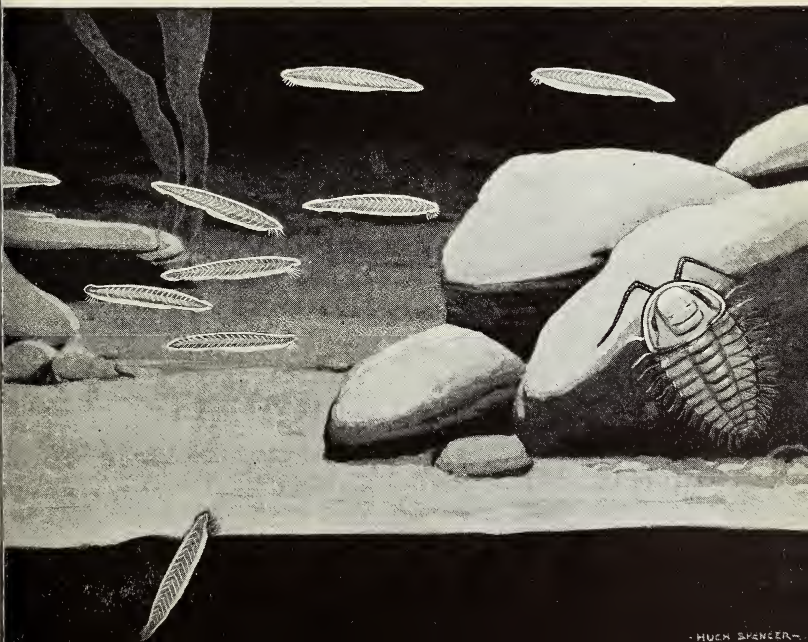
But there came a time when higher types, or kinds, of animals began to live. In some of the layers of rocks fossils

are found which show that little fishlike animals began to live in the water. They were the beginning of a large group of animals that had a system of bones with a backbone. Therefore the beginning of fishes was a very important event.

Let us find out more about animals with backbones. All animals are divided into two large groups: those without a backbone and those with a backbone. If you will notice the backbone of a skeleton, you will see that it is made of a number of smaller bones which fit together. These smaller bones are called vertebrae. Therefore, since backbones are made of vertebrae, animals which have backbones are called vertebrates. Animals which have no backbones are called invertebrates, which means "animals without vertebrae."

A bony skeleton is a very helpful thing to have. It not

These small fishlike animals began to live during the Age of Trilobites




A. M. N. H.

This is the fossil of an early kind of scorpion

only protects the body, but it also gives support to the muscles of the animal. Backbones of some animals make it possible for them to stand erect. Usually vertebrates have legs and arms that are fastened to bones which are attached to the backbone.

The first little animal that had something like a backbone was not a true vertebrate because it did not have a backbone made of real bones. It had something that was more like a cord running along its back. Men think that this animal was small and quite like those shown with the trilobite on page 137. It had the shape of a fish, but was quite different in other ways. It did not have a real head with a real mouth and jaws. Its mouth was just an opening that had little hairlike things around it which helped to take in its food. This animal did not have fins on its sides, but moved itself by movements of its body and tail. Its outside covering was skin instead of scales. There are relatives of this small animal living in our present-day fresh-water streams and in our oceans. They are thought to be very much like their early ancestors.

These first fishlike creatures probably lived in fresh-water streams and became numerous. For years they lived much as they had lived at first. Then many centuries later true fishes with real jaws and fins began to appear.

ANIMALS BEGAN TO LIVE ON LAND

About the same time that fishlike animals were beginning to live another animal, the scorpion, appeared and lived on the land. It might be difficult to decide which were the most important, the first fishlike animals or the first scorpions. The fishlike animals were the first animals to have a backbone of any kind. But the scorpions were probably the first animals to live upon the land.

The scorpions that lived in the water grew to be about three feet long. The smaller scorpions, about two or three inches long, were the ones that could live on land.

Those scorpions which lived upon the land were probably much like our scorpions of today. They breathed through organs which did the work of lungs. For this reason they were a higher type than the first kinds of animals.

Compare the fossil scorpion with this kind of scorpion which lives today (natural size)

U. S. B. Entomology and Plant Quarantine

THINGS TO THINK ABOUT

The very lowest kinds of animals are those that have only one cell. This cell has to take in its own food, air, and water. It must do all its own work.

Animals that are not so low have some cells which take in food, other cells which take in water, and still others which move the animals from place to place. The trilobites were one of the first known kinds of animals to have heads, legs, and other parts to their bodies. Since they had legs and

also heads with eyes and feelers, they were a higher kind of animal. You will find that as age followed age, higher and higher animals began to live upon the earth.

THINGS TO DO

1. Look at a group of animals. See if you can tell which have a backbone. Arrange the following list of animals in two columns, placing all the vertebrates in one column and the invertebrates in another: dog, earthworm, fish, man, snail, caterpillar, snake, fly, sponge, bird.

2. Mark off about **16½** feet more on your line. This is the time when shellfish, sponges, and trilobites were numerous. During this time there was more land above the seas than there had been before. Fishes were developing in the rivers and streams, and scorpions were beginning to live on land. Notice how the kinds of animals were changing.

The Age of Fishes

For millions of years after the Age of Trilobites the oceans swarmed with tiny one-celled plants and animals, with jellyfish, starfish, sponges, shellfish, corals, trilobites, and the first true fishes.

There had been many changes, however. Trilobites became more and more scarce. They were rapidly growing fewer both in kinds and numbers. It may be that they were not able to protect themselves against other animals. Perhaps some of the fishes had begun to use the trilobites as food. At any rate the time came when trilobites held a much less important place in the seas than they had held before.

During the same time the fishes developed until they were a very important group. They became more and more numerous. There came a time when fishes were more numerous than at any time before or since. Fishes were important not only because of their great numbers, but also because they were a higher kind of animal than the animals which had lived before them. This age is called the Age of Fishes.

The Age of Fishes lasted for millions and millions of years. And during all this time there were great numbers and many different kinds of fishes. Fossils show that sharks and armored fishes were numerous. The ancestors of our common fishes began to live then also.

Fishes were very well built, or adapted, for living in the water, especially fresh water. Water in streams and rivers is always flowing, and animals must be able to swim against this force. Can you imagine a jellyfish trying to swim up a stream? A jellyfish is so broad that the current would push too strongly against it. It would have a very difficult time. But fishes are long and slender. By swimming with their fins

and tail, they can cut the water and swim upstream against strong currents.

Probably fishes have lived through all these millions of years since their beginning because they were well adapted to life around them. In one way or another they have been able to secure food and to protect themselves from harm. Some have always been protected by being able to swim rapidly away from danger. Others are protected by having the color of their surroundings.

These fishes were living during the Age of Fishes.
How were they adapted for living in the fresh wate

American Museum of Natural History

Fishes are also protected by their methods of producing their young. Some fishes produce their young alive; the young ones are then soon able to swim about and hide from animals which otherwise would use them as food.

Most fishes reproduce their kind by laying eggs. Some of them make holes in the bottom of a quiet stream and lay their eggs there. Some fish, such as the salmon, live in the ocean most of their lives but go up fresh-water streams to lay their eggs. The fish called eels do just the opposite. They live most of their lives in fresh water, but go to the ocean to lay their eggs. In these travels they sometimes go hundreds of miles to lay their eggs where there will be the best chance of their hatching.

Sometimes a female fish lays from several thousand to several hundred thousand eggs. Since the number of eggs laid is so large, there is a greater chance that many will escape being eaten by other animals and will live to grow into adults.

A very few fishes build nests and some even protect them. Usually it is only the higher types of animals that protect their young. Few of the animals lower than the fishes give any protection to their eggs or young.

Fossils show that during the Age of Fishes seaweeds

were numerous in the seas and oceans. They were large and had many shapes. They furnished food for many of the sea animals. Smaller animals depended upon these plants to protect them from larger animals. When they were hidden in the seaweed, their enemies could scarcely see them.

We may know only a few of the animals that lived during the Age of Fishes. Many probably did not change their ways of living, as other living things and the climate changed about them. When a sea was changed or dried up, which sometimes happened in the earth's story, some animals did not change and become adapted to living on dry land. They became extinct. Sometimes adult animals could protect themselves but not their young. Animals cannot live on and on if their young are not protected and allowed to live. Those that in some way or other could not protect themselves or their young died. Many of them probably left no fossils. We know nothing or little about them.

At the beginning of the Age of Fishes there was a great deal of dry land upon the continents. However, soon after the age began, the land in places began to sink, and seas started to cover the land. This continued for millions and millions of years, until about the middle of the age. By this time much of the land of the continents was flooded. However, at the same time that some continents were being covered by water other land was rising out of the ocean; a good-sized continent was formed for a while around the north-polar regions.

After the middle of the Age of Fishes the seas began to go back and the land rose above the water. By the close of the period a large amount of the continents that we know were again dry land. Most of North America was again above water.

The climate in the Northern Hemisphere seems to have been mild during most of the period. Therefore, with warmth and plenty of rainfall, the conditions were very favorable for the many plants which grew then. They could have been found everywhere in and along the swamps and near-by valleys, as well as in the seas and oceans.

How should you like to take a trip into a forest of the Age of Fishes to see all these plants? If you would like to take such a trip, look very closely at the illustration of the plants in this age on pages 146 and 147. When you have noticed each one carefully, close your eyes and pretend that you are walking through the forest. Perhaps your whole class will be with you.

As you start along, someone remarks about how quiet it is along the swamp. Stop and listen! Of course you do not expect to hear birds because you know they have not begun to live upon the earth. But you did expect to hear other noises. The wind blows through the trees, rustling the leaves about you. The sound of the drip, drip, drip of a spring near by reaches your ears. A fish jumps, splashing the water. But there are no other sounds. Finally someone remembers that there are as yet no insects and no frogs to make any noise, and that the lower kinds of animals make no noise.

Now you notice the kinds of plants around you. Near you at the edge of the swamp and in damp spots you see tall plants that have joints in their stems. At each joint other stems or leaves grow in circles about the stems. Many of them are treelike plants. Look at them carefully to see if you can recognize them. Yes, they are horsetails, early relatives of the twentieth-century horsetails that you know.

There seem to be some trees to the left of you that look like ferns. Go closer. They are ferns. Can you imagine ferns

so large that they are trees? There are some smaller ones growing underneath the trees about you. The smaller ferns seem familiar, but not those giant tree-sized ones. Examine the tall ones. They really are not much like the trees you know, except in size. None of them have strong trunks made of wood as maples, oaks, and walnuts have. Their stems are soft and spongy.

Just in front of you, and a little to the right, are other trees. They are called club mosses or ground pines. However, they are neither true mosses nor pines. In our times relatives of this giant are all small plants trailing along the ground. They are seldom noticed and are almost lost among the taller plants. It is hard to believe that they were once those large trees that you see on this trip you are imagining.

This is the way men think a fores

If you pretend that you go on through the swampy forest, you will discover that ferns, horsetails, and club mosses are the principal trees. The leaves are not very numerous in this forest, and the trees let through a great deal of light. You miss the shade of oaks and elms. You decide that it is not at all like the forests you are used to.

THINGS TO THINK ABOUT

1. As millions and millions of years went by, some animals became extinct and other kinds developed.

2. The fishes were the highest kinds of animals that had ever lived upon the earth up to about the end of the Age of Fishes. They had backbones, and also special organs for breathing, eating, seeing, and moving.

ooked during the Age of Fishes

© F. M. N. H. From a painting by Charles R. Knight

The Coal Age

LATER PLANT LIFE

During the millions of years between the Age of Fishes and the Coal Age, plants on the earth were changing and developing as usual. Some of the same kinds of trees that you saw in the earlier forest grew also in the Coal Age, but they were much larger than their early relatives. The fern trees grew to be eighty and more feet high, or about the height of many of our common trees. Horsetails filled the swamps, many of them growing to be eighty or ninety feet high. However, there were some kinds of horsetails which were small.

Men have made this model to show what a cordaite tree was like

F.M.N.H.

Cordaites, similar to the one in the picture, were other great forest trees, which became extinct long ago. Nowhere in all the world can *Cordaites* be found. The giant redwoods in California, of which you will read later, are their nearest living known relatives.

Cordaites were huge trees, over a hundred feet high, with crowns of sword-shaped leaves. Like the seed ferns, they reproduced by real seeds. They were among the first trees that had cones like those of our pines, hemlocks, and spruces. These trees had stems that were a little more like the wood of our present-day

trees. It was less soft and spongy than the trunks of ferns. Slowly the kinds of trees were becoming more like the trees of our time.

WHAT HAPPENED DURING THE COAL AGE

During the Coal Age there were times when the surface of the earth was wrinkling; in one place land was sinking, in another place it was rising. As the land sank lower and lower, it became lower than the seas, and water came up over it until at last swamps were formed. At first the water was not deep enough to kill or drown immediately the trees, ferns, and other plants. They continued to grow as they stood in the water. Twigs and leaves fell from the trees into the water. Animals died, and their bodies were buried under the water.

Later, as the water crept farther and farther over the sinking land, the trees began to die. Some continued to grow for a while, as others fell at their feet. The fallen trunks added to the increasing supply of plant and animal matter, or material, in the bottom of the swamp. The land sank lower, and all these materials were covered with water. This continued until the plants of a once large forest were dead and covered.

Sand, mud, and clay were washed down on top of the plants, and little by little more sediment was added. Great storms caused water to rush in, bringing more soil. This mud and water kept the air away from the fallen trees and prevented their complete decay. Then, as years passed, more and more sand and mud were washed in from the higher country around until all the old plant life was far below the surface. The sand and mud were heavy and pressed upon the plant and animal matter, which was now farther down in the earth where it was hotter than at the surface.

How has the shape of North America changed since the Coal Age? Where was coal being made?

Many years afterwards this land beneath the swamp began to rise. It rose very slowly, only a few inches in a century. After many centuries it was again above sea level. The mud and sand that had been washed down into the swamp made a good place for plants to grow. Then, as in the past, a great forest sprang up, which grew throughout the year, during all seasons. Smaller plants, ferns, trees, and animals began to grow rapidly. They grew for many years, and some grew to be very large. By this time the land had stopped rising.

Then, after many centuries the land began to sink just as it had done before. Slowly it was once more lowered, and swamps covered many parts of the land that is now the United States and Europe.

This slow rising and falling of the land continued for thousands of years. Each time the land rose, a new forest grew; each time the land fell, a forest was drowned. At last after a long, long time there were many layers in the earth of trunks of trees, stumps, and plant materials, covered with mud, sand,

and clay. Each time a forest grew on top and soil was washed in, the pressure on the lower layers was increased.

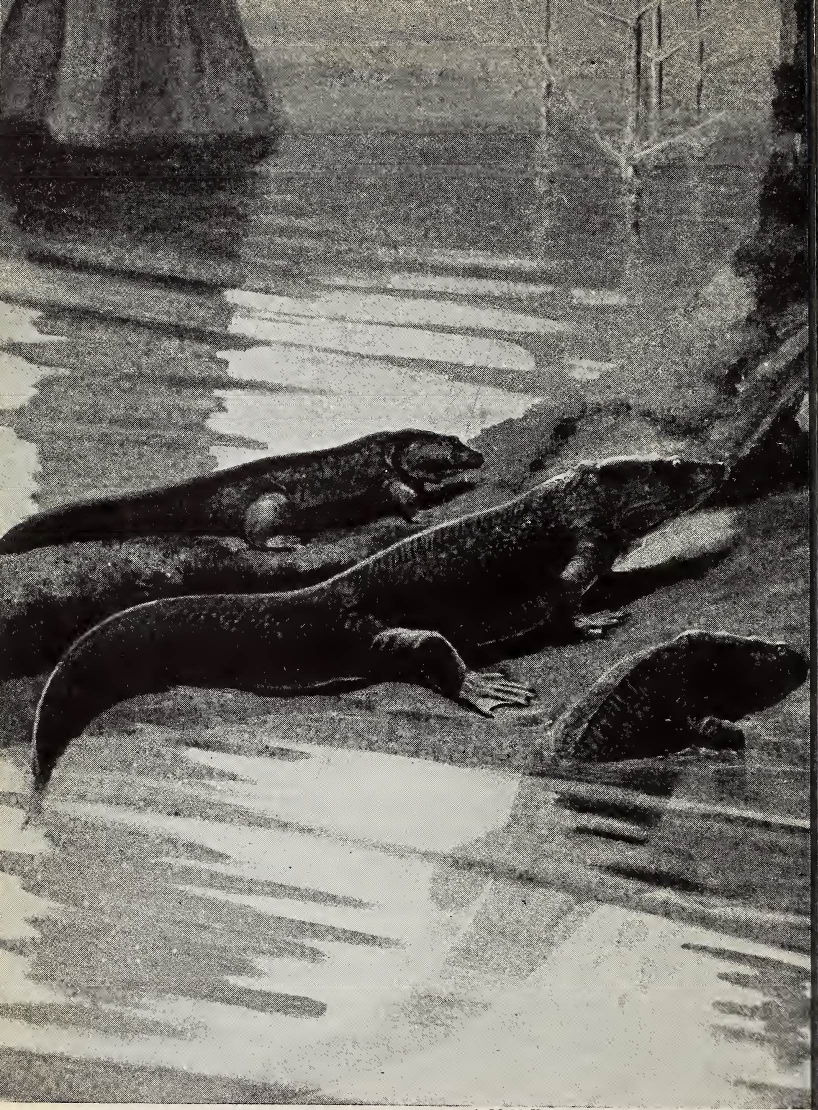
The plants that were covered on the bottom of the swamp began to change, as they were pressed harder and harder from above. The heat and pressure, after years of time, pressed out much of the water and changed the animal and vegetable matter into muck and peat. These are materials that have only partly changed to coal.

The muck and peat slowly became more and more changed. It was being pressed and heated, and heated and pressed, until almost all the water had disappeared. The substance that remained was coal. The map on the opposite page shows where coal was being made.

In this way great fields of coal were formed. Most of the coal that is now known was formed in the Coal Age in the United States, Europe, and China. There are many fields, however, in other countries. Coal fields have been found even in the antarctic country. It is from old forests and swamps that we receive the coal that is used today.

Several different kinds of coal were formed. You have learned that peat was first formed. When pressure and heat were added, the peat was changed to a kind of brown coal which had many other things in it. Later some was changed to soft coal. A great amount of coal that is mined now is soft coal. When the vegetable matter was under the greatest heat and pressure and was changed most, hard coal was formed.

Coal forms very slowly. Some scientists say that it may take about three hundred years for vegetable matter to collect and produce a coal bed one foot thick. The total thickness of all the layers of coal in some fields is about two hundred and fifty feet. It must have taken many, many centuries for so much coal to form.



A. M. N. H. From a painting by F. L. Jacques
Some of the early kinds of amphibians may have been similar to these

Later in the Coal Age some of the land under the swamps rose and formed mountains, and the water drained into seas and oceans. During the last part of the Coal Age much of the land had again come up above the water. That is why the coal that was formed in swamps is sometimes now found in mountains.

THE AGE OF AMPHIBIANS

The Age of Amphibians was a part of the Coal Age. It is thought that until that time most animals had lived in the water. You remember that the scorpion had started to live on land, but other animals continued to stay in the water. However, by the time of the Coal Age several kinds of animals, some of them called amphibians, began to live upon the land. You understand, of course, that they could not walk right out of the water and begin living on land. It took centuries for them to become adapted to living out of water. In the meantime many of them died because they could not change their way of living to meet the changes on the earth.

Although frogs and toads did not live in those days long ago, their ancestors were among the first animals that succeeded in living on land. These ancestors were animals that lived part of their lives on land and part in the water; such animals are called amphibians.

Amphibians usually lay their eggs in the water, where the eggs remain until they are hatched. The young animals spend the first part of their lives in the water. They breathe through gills in the sides of the head and have no legs. This fact makes amphibians still depend upon the water for at least the first part of their lives.

As they become older, legs grow out of their sides. Lungs take the place of gills, and the amphibians are then able to

live on land as adults. Often they stay close to the water, sometimes using the water as a place to hide for protection.

The earliest amphibians had two ways of breathing. They could use their gills in the water and could breathe through their lungs on land. This was a very important change from lower animals. They had legs to use in walking on the land and a kind of tail to use in swimming.

At first they had small heads and long slender bodies. They were somewhat like the common salamanders, a kind of amphibian which is found under rocks in streams. Some of the later amphibians, like those in the picture on page 152, were large with large heads and short heavy bodies.

Some of the amphibians were protected by a heavy outside armor. These animals were slow, awkward, and lazy. They had little need for other kinds of protection. However, some amphibians did not have this heavy outside covering for protection. They developed legs for fast running, and they were able to flee from danger.

This part of the Coal Age is called the Age of Amphibians, because of those animals that lived during that time. But at the same time new types of animals were developing. Some of these were later to become more important than the amphibians.

OTHER ANIMALS OF THE COAL AGE

If you could go back and walk around for a day in the Coal Age, you would find that a great many changes had been made since you visited the land in the Age of Fishes. Plants and animals had changed greatly. Some of them were getting to be more like those of our age.

This time at every step you would find insects, in the water, in the air, on the ground, and on plants. They were

the ancestors of our dragonflies, grasshoppers, crickets, beetles, and cockroaches.

We do not know at just what time insects developed. But considering the size of different insects and their number, scientists think that some of them must have been living on the earth long before the Coal Age, though sometime after the Age of Fishes.

Fossils of cockroaches show that they were very much larger than those of our time, some of them having been about four inches long. There were about five hundred different kinds, and all of them were meat-eaters. They lived upon smaller invertebrates and upon one another.

How different was this Coal Age forest from a forest of today?

Field Museum of Natural History

The cockroaches, however, were not the greatest giants of the day; they were just the giants of the cockroach family. The true giants of the meadows and swamps were the dragonflies. We think that we are seeing large ones when we see some that measure four inches across from the tip of one wing to the tip of the other. But we are told that during the Coal Age some of the dragonflies, like the one in the picture on page 155, would have measured two feet across.

Beetles of several kinds were living then also. And there were thousands of other insects. Many of the insects lived upon other animals instead of upon flowers and plants. Some of them lived by eating the leaves of the plants.

Animals of any age depend upon the kinds of plants which furnish them food. Since there were no flowering plants, it would have been impossible for the bees to find pollen and sweet juices. Bees did not develop until later, when there were flowers.

It is thought that there were no insects, except possibly the cricket, that could make a noise. We know that there were no birds, and the world was without their songs. Probably the only animal noise would have been the chirping of the crickets.

The first reptiles, the early relatives of the snakes, began to live at this time. They were better adapted for living upon the land than amphibians. They were probably the first vertebrates that laid a kind of egg that could hatch on land. When the young reptiles were hatched, they were able to live their entire lives upon the land. You remember that most amphibians must spend part of their lives in water as tadpoles. Therefore the development, or appearance, of animals that could pass their entire lives upon the land was very important.

THINGS TO THINK ABOUT

1. Club mosses that once grew to be one hundred feet high in the forests of the Coal Age are about six inches high in some forests of today.

2. Why is coal sometimes found in hills and mountains, when it was formed in swamps?

3. When you use a shovelful of coal, think about where it might have been formed. Does it take as long for it to burn as it did for it to form?

4. You have read that during the Coal Age forests in swamps died and were covered by many feet of soil. Later the land was raised out of water and new forests sprang up. Where did the seeds come from which grew into the new forests? How could a new forest grow?

5. As in the past, coal is being formed today. Peat may be found in different parts of the world. In the swamps of Florida, Virginia, and North Carolina, peat is being made at the present time. It is forming very, very slowly.

THINGS TO DO

1. Add $13\frac{1}{2}$ feet to your line of the picture story of the earth. This includes the Age of Fishes and the time of the amphibians, of the insects, and of the greatest coal-making. Near the last part of this age the earliest reptiles appeared. The Appalachian Mountains arose also toward the end of this age. At the end of this part of the line you may place the words "End of the Paleozoic (Ancient Life) Era." The Paleozoic era includes the last 30 feet you have marked on your line. If you draw any pictures for this part of your line, show the changes in animals during the era, and also show the building of mountains.

VI

Life Continued to Develop

THE AGE OF REPTILES

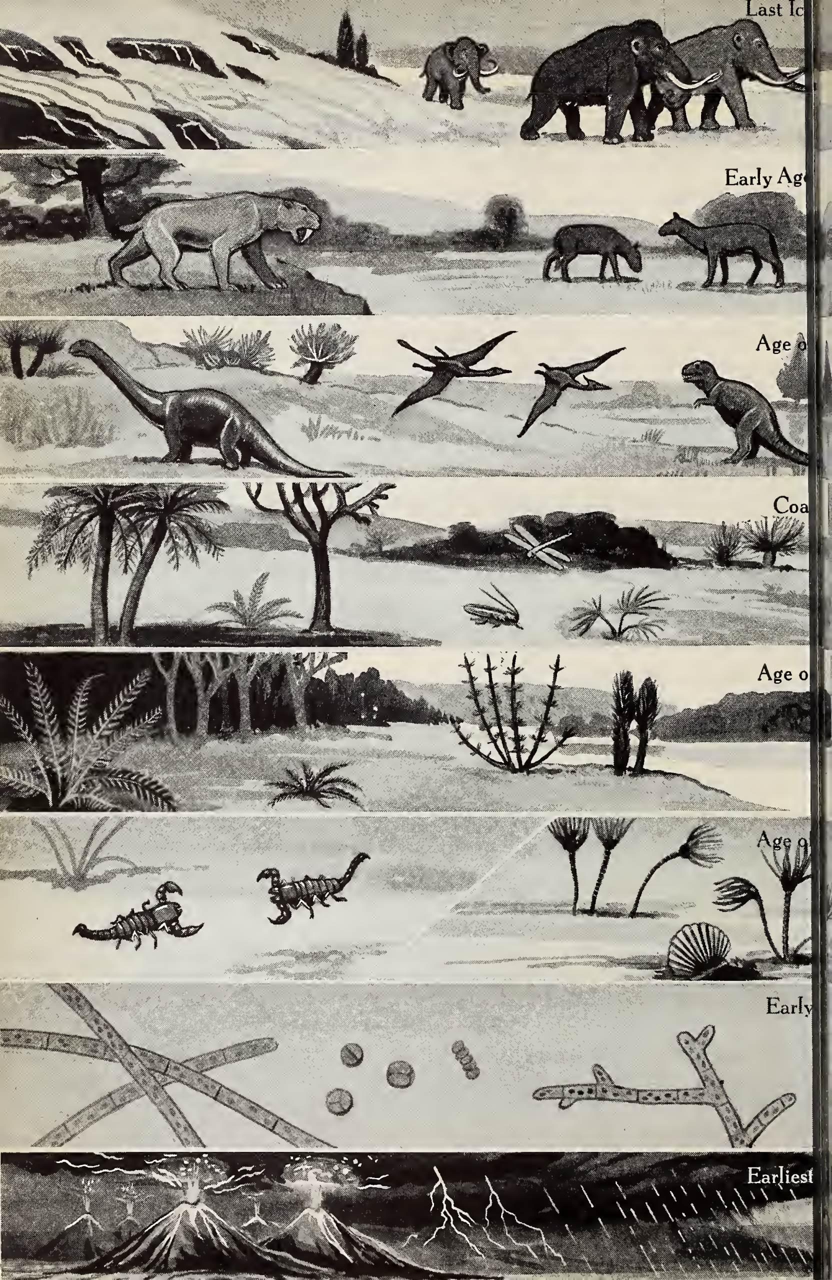
THE RISE OF MODERN PLANTS

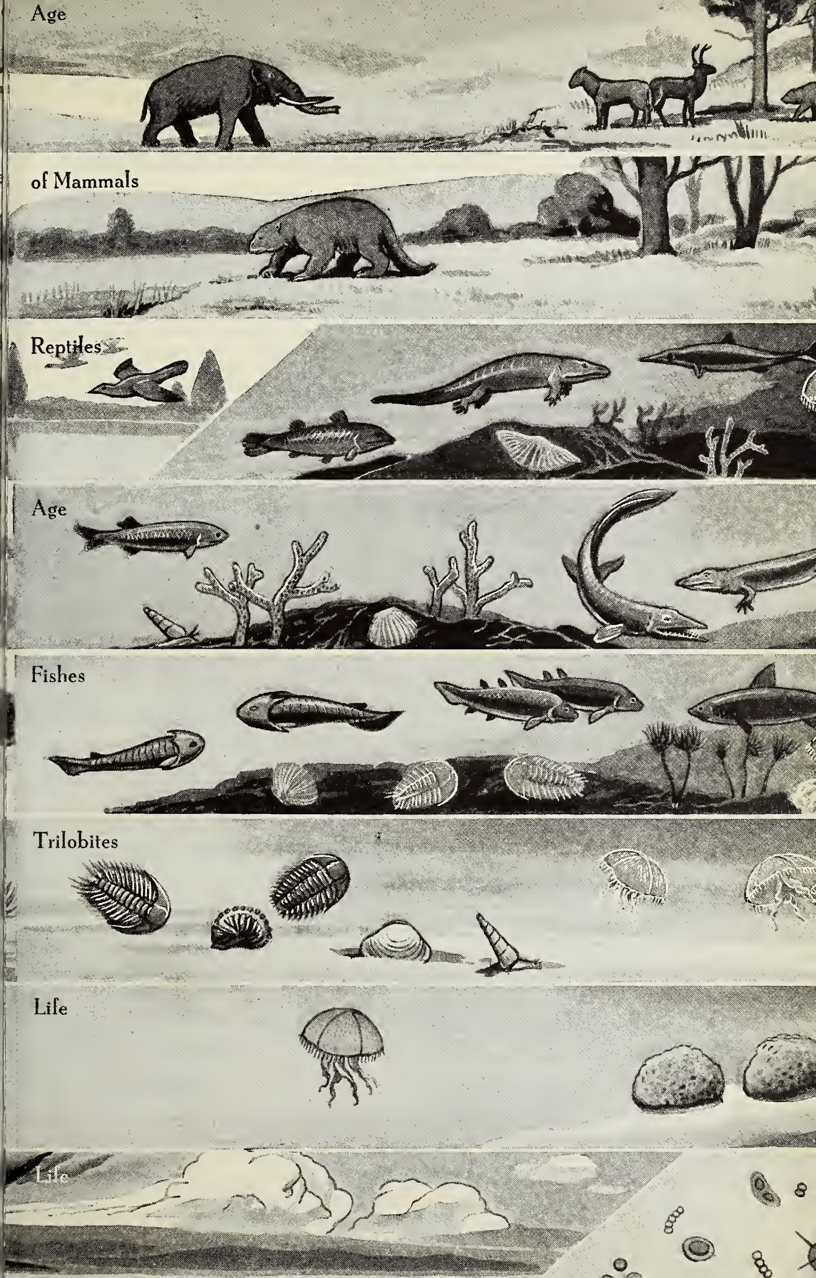
THE FIRST WARM-BLOODED ANIMALS

GREAT changes followed immediately after the Coal Age. There had been times during the ages of trilobites, fishes, amphibians, and of coal-making, when great changes took place. There had been times of severe cold, when ice sheets covered large parts of North America. At other times there had been dry climates. Great movements of the earth's surface had pushed up mountain ranges. But all these changes were scattered over many ages, one or two occurring in one age, some in another.

But following the time when the greatest layers of coal were formed, these changes were taking place rapidly one after another or they were taking place in different parts of the earth at the same time. During this period the region where the Rocky Mountains now are became covered with seas. A region in the eastern part of the United States that had been covered by seas became folded up into the Appalachian Mountain system with much higher mountains than at the present time. These mountains extended from Alabama to Newfoundland. At one time or another great ice sheets formed over large areas of Africa, Asia, Australia, and South America, and perhaps some parts of North America.

These changes in surface and climate probably had great effects upon the plant and animal life in the different regions. If you will look at the illustration on the two following pages, you will notice how life upon the earth had changed from one age to another. Notice the life during the age marked Age of Reptiles. Many of these animals are very different from those which lived before. Great changes occurred in the animal life in this and the next age. The next two units tell of many of these changes.


Last Ic
Early Ag
Age o
Coa
Age o
Age o
Early
Earliest


Age
of Mammals
Reptiles
Age
Fishes
Trilobites
Life
Life

The Age of Reptiles

Some kinds of reptiles that had appeared in the Coal Age continued to live in spite of all the changes that took place on the earth's surface. They were so well adapted that there came a time when reptiles were almost everywhere.

Huge reptiles walked on land. Others with wings, similar to the wings of bats, skimmed over land and sea in search of food. Still others lazily swam or half floated through the water, looking for something to eat. The name which scientists have given to many of this family of early reptiles is dinosaurs.

There were small dinosaurs that could run swiftly. They ran on their hind legs and stood almost erect. Others, very much like them, grew to enormous sizes, sometimes eighty feet and more long. Some of the largest dinosaurs walked on four feet and were very clumsy and awkward. These reptiles continued to grow slowly as long as they lived.

There were two chief classes of dinosaurs. One group fed upon leaves of trees or ate plants that grew along the banks of rivers or at the bottoms of swamps. The dinosaurs called *Brontosaurus*, *Stegosaurus*, and *Triceratops*, which are shown in the picture, belonged to this group. The others were flesh-eating animals, some of which were giants with teeth six inches long. They ate the vegetable-eating reptiles and other animals that could not protect themselves. *Allosaurus* and *Tyrannosaurus* belonged to this group.

Not all the early reptiles lived on land. Some lived entirely in the water. *Ichthyosaurus* was a fishlike reptile. His paddle-like limbs made it easy for him to go through the water. His head was made in such a way that he could catch fish very easily.

A long time passed after the first reptiles appeared before any of them developed wings. The pterodactyl, which is sometimes called finger wing, was one of the flesh-eating, flying reptiles. It is sometimes also called the dragon of

Notice the long sharp spines on the tail of *Stegosaurus*, and the three horns on the head of *Triceratops*. They were used for protection

the air. The picture shows that it had no feathers, but it had a membrane, or skin, stretched over its arms and fastened to one very long finger to form a kind of wing. Some pterodactyls had long tails; others had very short ones. They may have eaten fish and insects.

Some of these flying reptiles were small; others were large. The smallest were about the size of one of our common sparrows or swallows, while others were larger than any birds that we know. When these largest ones stretched their wings, they measured thirty feet from tip to tip. That is larger than some of our small airplanes.

None of these animals are living now, and the only way we learn anything about them is by the study of the fossils that have been found. Landslides which covered these animals or sediment that was washed over them kept the air away from them, and their bones were left as fossils.

Fossils of dinosaurs have been found in many parts of the earth, on every continent and in New Zealand. Many have been discovered in the western parts of the United States.

Why could the Allosaurus kill and eat other large animals?

© A. M N. H. From a painting by Charles R. Knight

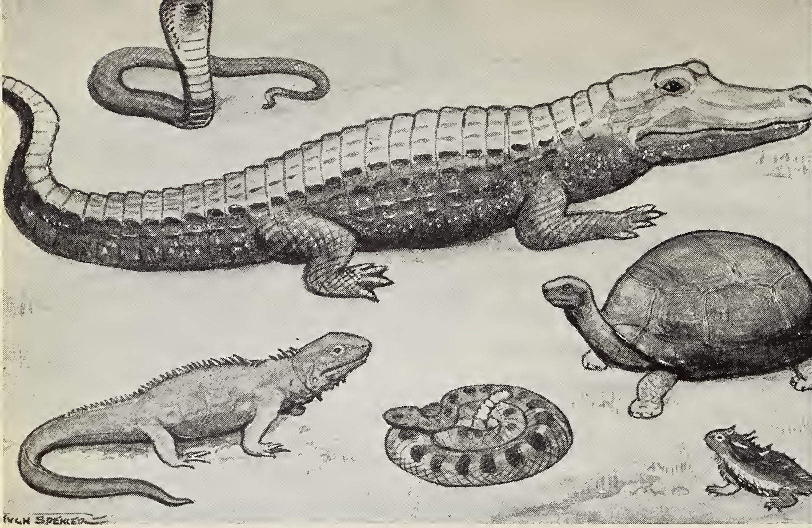
© F. M. N. H. From a painting by Charles R. Knight
These pterodactyls were not the largest or the smallest of the flying reptiles

The dinosaurs lived there before the Rocky Mountains were formed, at a time when that country was level and covered with lakes and tropical plants. In the western part of the United States eighty acres of land have been set aside as the Dinosaur National Monument. This park has many fine fossils of dinosaurs, and from them men will probably learn other interesting things about these animals.

These early kinds of reptiles did not continue to live upon the earth. Little by little they became fewer and fewer until there were no more living; that is, they became extinct. We are not sure just why they became extinct. Perhaps the vegetable-eating ones were so large and needed so much food that they finally starved. It may be that the flesh-eaters of the group ate all the plant-eating dinosaurs and then ate each other until there were not enough left to reproduce more dinosaurs.

Perhaps they depended too much upon their size to protect them. They had very small brains in comparison with their size, and it may be that they were not quick enough or clever enough to avoid the animals which fed upon them.

Perhaps changes in climate and on the earth's surface made it difficult for the dinosaurs to live. At the close of the Age of Reptiles mountains were pushed up along the entire western coast of both North and South America. The Rocky



Compare these reptiles which live now with their early relatives, the dinosau

Mountains were formed in the very regions where swamps had been the home of the dinosaurs. But whether it was because of a general rising of land or other reasons, something caused the dinosaurs to become extinct.

Whatever it was that caused the dinosaurs to die out, it did not have the same effect upon some of their smaller relatives living at the same time. They continued to live, and their kinds are living in modern times.

Reptiles of the earth now are the crocodiles, alligators, lizards, snakes, and turtles. There are more than 4000 kinds living today, although most of them are midgets when compared with their ancient relatives.

Reptiles are much more highly developed than the group of animals which lived before them. You remember that fish breathed in water. And amphibians had to spend the early part of their lives in water. But both young and old reptiles

breathe air by means of lungs. Though some reptiles live in the water, they still must have their nostrils above water to breathe.

Most reptiles lay eggs, which they leave in the sand or earth for the warmth of the sun to hatch, or they cover the eggs with plant material which decays and produces heat. Even turtles, crocodiles, and alligators leave the water to lay their eggs. A few reptiles, such as the garter snakes, do not lay eggs, but give birth to their young, sometimes to as many as thirty at one time.

THINGS TO THINK ABOUT

1. The largest land animal we know today, the elephant, often weighs about five tons. *Diplodocus*, one kind of dinosaur, sometimes weighed ten times as much as an elephant, and yet it became extinct in spite of its size.

2. Some kinds of animals are better adapted to their surroundings than others. Dinosaurs were not so well adapted to their surroundings as their smaller relatives were, and so they died out. Perhaps they had become too large. They may have needed too much food. Their weight may have made them awkward and unable to escape danger.

3. The changing climates and land movements that occurred during the latter part of the Age of Reptiles probably affected many animals. It may have helped to cause the dinosaurs to become extinct.

THINGS TO DO

1. Compare the dinosaurs with reptiles that are living now. Do you think the modern reptiles are better adapted to their surroundings than the dinosaurs? Is there a possibility that some reptiles you know may become extinct?

2. Compare reptiles with kinds of animals that began living before reptiles did. Name the ways in which reptiles are better adapted. Tell how they are not so well adapted.

The Rise of Modern Plants

During the first part of the Age of Reptiles, ferns and horsetails were still common. But they were much smaller than their early relatives which had lived in the Coal Age.

A higher group of trees was beginning to be the most important of the plants. These trees were the cone-bearing kind. *Cordaites*, which lived in the Coal Age, had belonged to this group. They were about the first of their kind. Now there were others which grew their seeds in cones. One of these was the kind called cycads.

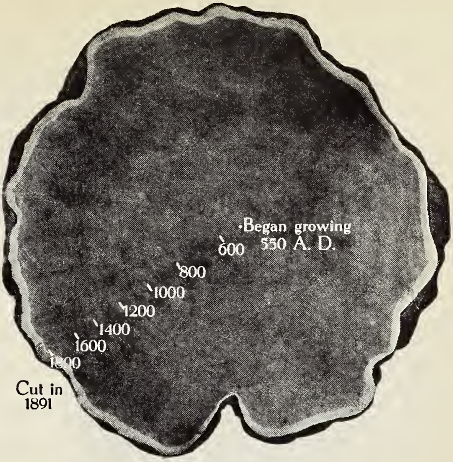
A few cycads are living in several parts of the world today. They give us an idea of what their ancient relatives were like.

A few living cycads are somewhat like palms or ferns, but usually they have strong trunks made of wood that grow straight up without branching. Leaves come out at the top of a tree and form a crown. Some cycads have a stem, or trunk, that grows entirely under the ground. The leaves spread out above the ground, similar to those of a radish, turnip, or carrot. Other cycads have trunks that grow to be from twenty to fifty feet high. Their trunks are a foot or more in diameter. At the top of these trees grows a cluster of large leaves that are cut into narrow divisions.

Notice the places where the old leaves have fallen off of this cycad, which lives in Florida

McFarland

Cycads do not drop their leaves in the autumn. They are like evergreens. As the leaves grow old, they fall off one by one during any season. As the cycad leaf falls, it leaves the base of the stem where it was fastened to the trunk. These bases collect and form a protection for the trunk of the tree.



How old was this redwood tree when it was cut?

These plants live to be very old. One cycad that is six feet high is believed to be a thousand years old, and it is still living.

The cones of cycads are often of very bright colors, orange or yellow, and they stand straight up in the middle of the top of the tree.

There were other trees during the Age of Reptiles that produced cones and began to be more like the present-day cone-bearing trees. Some of them were early relatives of the big sequoias that grow in California now. In the latter part of the Age of Reptiles, the sequoias grew in many parts of North America, Europe, and Asia. But with the changing climates and the glaciers that followed, they failed to grow anywhere except in one place in the Sierra Nevada region.

These trees are probably the oldest living things known. When their trunks are cut crosswise, like the one shown here, there are rings which show how much the tree grew each year. These annual rings of growth show that some of them are

McFarland

An early relative of this ginkgo tree lived during the Age of Reptiles

from two thousand to three thousand years old. By studying these rings men have learned how to tell something of the climates and amount of rainfall during different years in the life of the trees.

Sequoias are the largest known of the cone-bearing trees. The redwoods, which are one kind of sequoia, are sometimes from three hundred to three hundred sixty feet tall, and their trunks are usually from ten to fifteen feet in diameter. One tree has been found that is three hundred eight feet high and has a trunk twenty feet thick and red bark eleven inches thick. It is believed that there is wood enough in that tree to furnish the lumber necessary for building twenty-two houses of ordinary size. Another redwood is three hundred sixty-four feet tall. It is the tallest tree in the world. The tree that has the largest diameter of any tree is over thirty-seven feet through.

These trees have been able to live through many conditions which would kill other trees. They are most unusual because insects do little injury to them. Then also, sequoias do not burn easily. The wood contains a good deal of moisture instead of the kind of sap which makes many evergreens burn easily. Perhaps these facts have helped them to live so long.

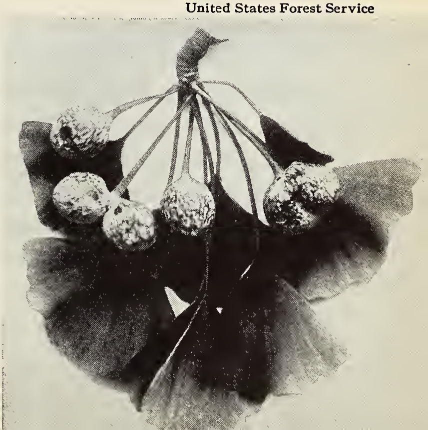
The worst enemy of the redwoods has been man. At an early date men cut down hundreds of trees for lumber. Since that time the forest has been made a national park, and the trees are protected. They will probably live for many more centuries.

The ginkgo is another kind of tree whose relatives have lived through many millions of years, from the Age of Reptiles to the present time. Today it is the only living species, or kind, of a large family of trees that grew in many parts of the world.

The ginkgo tree has had a most unusual history. It has long been held as a sacred tree in Japan and China. The people planted ginkgoes around their temples and cared for them. In this way this species has been saved. From China and Japan it has been taken to many other countries, where it is used as an ornamental and shade tree. Lately wild species of ginkgoes have been reported found in some of the mountains of China, but it is doubtful whether they grow wild in any other place.

The ginkgo trees of the present time probably have come down directly from those trees that lived during the Age of Reptiles. They are probably the oldest species, or kind, of living trees that have come down to us without many changes. Perhaps for ten million years ginkgo trees have looked almost exactly like their ancestors of so long ago. It would be almost impossible to tell the

This shows the leaves and fruit of a ginkgo tree
United States Forest Service



difference between the prints of the ancient leaves and the prints of the leaves of today, like those shown on page 171.

The logs of stone in Arizona, which you read about earlier in this book, were a living forest during the Age of Reptiles. The many fossil logs that are scattered over this region tell a great deal about some of the trees that grew millions of years ago.

None of these trunks have branches remaining on them. All the branches had been broken off and most of them destroyed; but a few petrified, or stone, branches are found scattered about over the ground. We do not know exactly how these trees looked, but they were a kind of pinelike tree that bore cones. They became extinct in North America ages ago.

Fossils have been found of about four hundred kinds of plants that lived a little later in the Age of Reptiles. During this period, as plants were developing, each new plant became more like plants that we know. At the time that ferns, cycads, sequoias, and ginkgoes were most numerous, the land was covered mostly with green. There had been no colorful flowers on the earth in the millions of years of the earth's story.

Then slowly new kinds of plants developed which added many colors to the earth. These were the flowering plants. The fields became filled with color. These new species of plants were to grow upon the earth during all the ages to come. Ferns and cycads began to be smaller in size and number as flowering plants increased. Flowering plants were the last and highest group of plants to develop.

Have you ever noticed honeybees and other insects swarming around magnolia or maple trees or other plants when they were flowering? If so, you know something of how

Galloway

These honeybees are getting food from the roses

necessary flowering plants are to these insects. With the coming of the flowers it was possible for honeybees, moths, and butterflies to live. They darted from flower to flower, like the bees in the picture above, searching for the sweet juice of the flowers, on which they lived. Therefore not only the last group of plants known but also the last great group of insects developed before the end of the Age of Reptiles.

THINGS TO THINK ABOUT

1. The changing climates and land movements during the last part of the Age of Reptiles did not have the same effects upon most of the plants that they had upon many animals of the time.

2. Kinds of plants which produced seeds from flowers had begun to grow during the last part of the Age of Reptiles. They were a higher group of plants than the ferns and club mosses. They are the highest group of plants known.

3. Early ancestors of some of our modern trees had begun to live during the Age of Reptiles.

THINGS TO DO

1. In the early spring notice the flowers that come out before the leaves on the elms, maples, and other trees. Watch the changes that occur before the seeds are fully ripe. Look at the pictures on page 190.

2. Look at a cone from an evergreen tree. Can you find any seeds in it? Compare it with the seeds or seed pods of other trees.

3. Count the rings on a tree that has been sawed in two. Can you tell which rings were formed during rainy years and which during dry years? Do you notice that some are thicker than others? Would they have grown more in dry or in rainy years? This is one way scientists have of learning about climates of the past.

The First Warm-blooded Animals

THE FIRST BIRDS

Hiding among the leaves of trees during the last part of the Age of Reptiles lived another kind of animal. It was different in some ways from anything which had ever lived before. It was the beginning of a very highly developed group, which has continued to live into the present time. As you read about it, see if you can guess what kind it was.

Until this time all the animals—the trilobites, fishes, scorpions, amphibians, and reptiles—were cold-blooded. That is, they were just about as warm or cold as their surroundings. But this new animal was a warm-blooded creature. No matter how cold or how hot the weather was, the temperature of its body remained about the same.

It also differed from other animals in another way. An amphibian's body had a moist slimy skin. Some animals had hard skins or even shells covering them. Reptiles had tough dry skin or scales. But this new animal had a very different covering; it had feathers. And now you have guessed that this new animal was a bird. The feathers helped the bird to hold the heat in its body, and helped it to stand the severe cold of winter.

Fossil skeletons of the first kind of birds are found in the same layers of rocks in which other fossils of the Age of Reptiles are found. They show that while dinosaurs were numerous on the land and water the first birds were beginning to live.

One of the first kinds of birds is called *Archaeopteryx*. Its fossil skeleton shows that it was a small bird, about the size of our common crow or pigeon. It was not nearly so large as

most of the flying reptiles that flew and glided through the air during the same time.

Although *Archaeopteryx* was different from the birds you know, you probably would have recognized it as a bird. Only certain parts of its body were covered with feathers. The wings and tail were covered. There were also a few feathers on the back, but there were very few, if any, feathers on the head. Its tail was longer than the rest of the body, and the feathers on it were very long. It is shown on the opposite page with a crow.

Except for the feathers, the wings looked somewhat like the wings on the flying reptiles. The wings had claws that the bird used for holding on to the branches of trees. Perhaps it used these claws for climbing.

This early bird differed in other ways from modern birds. It had jaws that contained many small teeth, which the birds used to catch fish and other animals. Its head was small, with very large eyes.

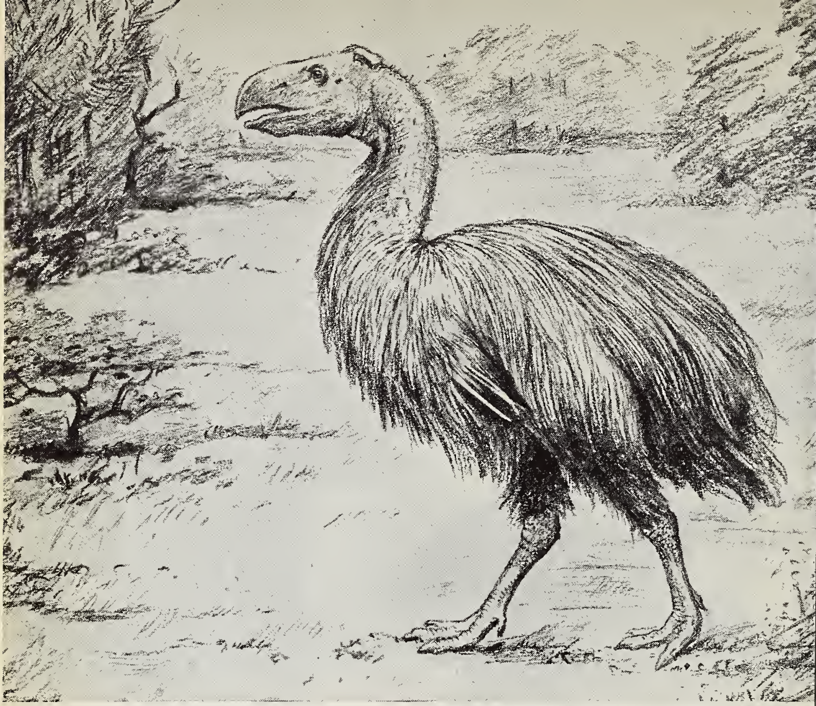
Like many other animals before it, *Archaeopteryx* finally became extinct. But some of its near relatives continued to live upon the earth. Today there is a bird living in South America which has claws on its wings that it uses to climb trees. This bird cannot sing, but makes a very harsh, croaking noise. Since it is somewhat similar to *Archaeopteryx*, some people think that the extinct bird made a croaking sound, but could not sing.

Other birds a little more like our modern kinds soon developed. Only a few fossils of these have been found, and they show that birds soon became quite different from *Archaeopteryx*.

Some were very small flying birds. Others were water birds. One, whose fossil was found in Kansas, was a very

What are some of the differences between *Archaeopteryx* and the crow?

good swimmer. Its toes were partly webbed, which helped it in swimming. It could swim through the water with great speed and could dive very easily. This bird also had long slender jaws set with sharp teeth. It caught most of its food in the water.



A. M. N. H. From a restoration by Erwin Christman

This giant bird lived long ago

Giant birds also developed, some of which were eight or ten feet tall. Their wings could not hold them up in the air; but they did not need to fly, for they had long, strong legs that carried them rapidly over the ground. They had strange heads that were almost two feet long and looked somewhat like a horse's head. One of the largest of these birds was the elephant bird. Later, birds like the one shown here began to live.

Although several kinds of birds had developed, there were as yet no birds that could sing as the birds do today. Birds became able to sing as they grew to be more like modern

birds. Would it not have seemed strange to see any number of birds and not hear a song from at least one of them? The nearest thing to a song which the first birds could produce was just a croaking noise.

As birds developed into the birds we know, they became very well adapted for their ways of living. Have you not often wondered why birds can fly and other animals cannot? That is because they are specially built for flying. Their bodies are slender and built in such a way that they can go through the air quite easily. Feathers on the wings give the wings a large area for air to strike and hold up.

Birds are also built on the inside in such a way as to help them in flying. Most of the bones are hollow and filled with air, which makes them light. The body also has a number of places called air sacs which are filled with air and help to make it lighter.

You remember that many reptiles lay eggs and then go off and leave them. The young reptiles which hatch must be able to care for themselves or they will not live long. Birds also lay eggs. But most birds sit on their eggs and care for them until they are hatched. Then the parent birds feed the young birds until they are ready to care for themselves. Perhaps this is one reason why birds have continued to live on the earth.

You can think of birds living in all kinds of places; and if you will look at them or at their pictures, you will see how well adapted they are to live where they do. Perhaps it is for this reason and their ability to fly that birds are scattered over so much of the earth.

MAMMALS APPEARED DURING THE AGE OF REPTILES

At the same time that the giant lizards and flying reptiles were numerous on the land, in the sea, and in the air, and *Archaeopteryx* was struggling to live, other animals scarcely as large as rats sped swiftly along the ground. They probably dodged from one hiding place to another quite unnoticed, as they hunted for food and kept away from their enemies. But these tiny animals probably had a hard struggle to keep alive in a land where there were many very large as well as small animals.

Fossils of the teeth of these animals have been found which make scientists believe that these dwarflike animals ate juicy grasses and roots which they found along the ground. They also ate worms and insects. They robbed the nests of birds and lizards and ate the eggs or young. It is believed also that most of them climbed trees and ate any seeds, nuts, and fruits which they found there.

Up to this time no mother animal ever had food in her own body with which she could feed her young. But the mothers of this new group produced milk in their bodies, and fed their young until they were old enough to search for their food. Animals that feed their young on milk are called mammals, and these small animals were the first mammals that ever lived on the earth.

These early mammals laid eggs, and it is thought that they remained with the eggs until they were hatched. After that the mothers nursed the young and protected and cared for them until they were large and strong enough to care for themselves. Since the mothers fed them and protected them from danger, a larger number of the young succeeded in living.

The text on page 183 tells about this spiny anteater

Early mammals differed in another way from all the animals that had lived before. They were the first fur-bearing animals of which we know. Birds had a covering, too; but it was made of feathers, not fur. Birds had developed feathers and were warm-blooded, but no fur-covered animal had ever lived before that time.

These early egg-laying mammals were so small that if one of them had stood by the side of a great dinosaur, it would have looked as small as a good-sized cockroach would look beside a man. Their small size, speed, and ability to keep away from the giant animals probably helped to protect them.

These kinds of animals lived for many centuries, but only a few kinds were able to protect themselves enough to live

A. M. N. H. From a painting by F. L. Jacques

This is an early relative of the opossum, which is a marsupial. The text tells about marsupials.

through the following ages. However, there are two kinds of animals in Australia and Tasmania that may have come down from these early creatures. They are the duckbill and the spiny anteater. Both are egg-laying mammals. Out of several hundreds of different kinds of mammals living on the earth today, these are the only two that lay eggs.

The duckbill is a small, brown, furry animal about a foot long. It is named this because of its ducklike beak, about two inches wide and two and one half inches long. With this bill the animal stirs up the mud at the bottom of the streams of water, and catches the tiny shellfish and insects it finds there. Duckbills have webbed feet and spend much of their time in the water.

They burrow into river banks, sometimes as far back as fifty or sixty feet. At the end of the burrow they make a nest of weeds and grasses from the river. Here the female lays from one to three eggs, which hatch into tiny, naked, helpless young duckbills. They feed on milk from the mother's body until they are strong enough to leave the burrow and take care of themselves.

The spiny anteater is a few inches longer than the duckbill and is covered with spines similar to a porcupine's. This little animal lives in the forest where, with its claws, it turns stones and logs searching for ants. Then with its long sticky tongue it snatches these little insects into its beaklike mouth and continues its search for more food.

The female anteater lays one or two eggs, which are placed in a little pocket on the underside of her body. Here the eggs hatch and the young feed on milk for several weeks before they can hunt for food. Notice the illustration on page 181 to see how this animal is protected.

Later during the age when the first mammals developed

another class of mammals, called marsupials, appeared. They were animals whose young were born alive, as most mammals today are born. But these mammals carried their young about in a little pouch, or bag, that the mother had for that purpose. The young of marsupials were not fully developed when they were born and were carried in the pouch until they were large enough to care for themselves.

THINGS TO THINK ABOUT

1. Before the Age of Reptiles all animals had been cold-blooded. They were about as warm or cold as their surroundings. During the Age of Reptiles warm-blooded animals developed. They kept about the same temperature in spite of changes in their surroundings.

The kangaroo is a marsupial. You can see one of its young, which it is carrying in its pou

2. Warm-blooded animals are more highly developed animals than cold-blooded animals.

3. Can you think of any reason why birds and most mammals, which are the only warm-blooded animals, have a covering of feathers, fur, or hair?

4. To what group of animals does man belong?

5. How did the early birds and mammals differ from modern kinds?

THINGS TO DO

Mark off 11 feet on your picture line. At the end of this part of the line place the words "End of the Mesozoic (Middle Life) Era." This era was not so long as the eras before it, but there were a great many changes both in plants and animals and in the surface of the earth. You will want to think about only the most important changes. During the middle of the age when the dinosaurs were most common, great parts of the surface of the continents were swampy and under water. The Appalachian Mountains had been worn down to low hills. At the end of the age they were again pushed up somewhat. But the greatest mountains built at that time were those along the Pacific coast of North and South America. The Rocky Mountains were formed by earth movements and by volcanic action.

Very tiny mammal-like animals were found in the early part of the age. Later on in the age they were about the size of rats.

Early birds developed during the middle part of the period and some grew to quite large sizes by the end of the age.

VII

Plants and Animals of Recent Times

THE AGE OF MAMMALS

THE LAST ICE AGE

YOU have learned about several great ages of the earth's history—the Age of Trilobites, the Age of Fishes, the Coal Age, and the Age of Reptiles. These are some of the ages since life began on the earth. There were other ages before life began. Each age was probably millions and millions of years long.

If you could go back in time and see the earth during each of the ages since life began, you would find a few living things that would be quite similar to some things living about you now. A few one-celled plants and animals, sponges, shellfish, mosses, ferns, fish, and others that are somewhat like their modern relatives have lived in the different ages. Some lived in several ages; others lived from almost the first age when their kinds began.

But you would see many more kinds of living things that had changed greatly. You would see many kinds of plants and animals that have since become extinct. You probably would also notice some of the changes on the surface of the earth that affected the plants and animals living in past ages.

If you could make a long visit to the earth during the time of the Age of Reptiles and continue to live during the age that followed, you could watch the animals as they slowly became more and more like those of recent times. The scene would change slowly, until finally there would be a scene very much like the picture following this page, with trees and animals like ours today.

The Age of Mammals

MAMMALS BECAME MORE LIKE THOSE OF TODAY

The millions of years since the Age of Reptiles is called the Age of Mammals. By the beginning of this age all the large groups of plants and animals had begun to live; no great group has since developed. However, this does not mean that the plants and animals at the beginning of the age were the same as those we know today. No, indeed! But some kinds of all the groups to which plants and animals of today belong were living at the beginning of the Age of Mammals.

Ever since the beginning of the Age of Mammals the highest kinds of plants have been those which produce their seeds from flowers. The lilies of the swamp, the pansies in

The first picture shows the flowers and seeds of an elm tree.
The second picture shows the flowers and seeds of a maple tre

the garden, the flowers of the meadow, and many trees of the forest produce flowers. Sometimes it is difficult to see them. Often you do not recognize them as flowers when you do see them. If you will watch trees and other plants in the spring and summer, you will learn a great deal about their ways of making seeds. Have you ever seen flowers and seeds like those in the picture on page 190?

Plants have changed a great deal since the beginning of the age. Many kinds have become extinct. Many others have developed. But, so far as we know, no entire class of plants has disappeared, once it made a good start upon the earth. Some of each group of living things have failed to live, but others have lived on and on.

During the Age of Reptiles mammals were very small and unimportant. Their brains were small compared with their bodies. Mammals, during the Age of Reptiles, probably had a very difficult time trying to protect themselves and to live. Only a few kinds succeeded in living into the next age. However, they were the beginning of the mammals that live today.

Dinosaurs had lived upon the land for a long, long time, while mammals scarcely counted in the animal world. But, as you have read, there came a time when these reptiles were not so great and so strong as they had been. Their kind began to fail and later became extinct.

At the same time that dinosaurs were becoming extinct, mammals began to develop greatly. Just why they developed we do not know. Perhaps it was partly due to food and climate. During the Age of Reptiles grasses had started to grow, and by the Age of Mammals they grew in great quantities. Some of the mammals which developed were those that live on grasses.

The climate also was very favorable during the first part of the age. It was very much warmer in Greenland, North America, and Europe than it is today. This is shown by the fact that palms and figs, which need a warm climate, grew farther north in the United States than they do now. Many plants which grow in Virginia or the Carolinas at the present time, grew as far north as parts of Greenland. The climate may have helped the mammals in their growth.

Perhaps there were other reasons why mammals succeeded so well and became so numerous. They were not like the egg-laying mammals and marsupials that had lived during the Age of Reptiles. Their brains were larger and better developed. It did not take their young so long to be able to care for themselves. In several ways they were more highly developed than the first mammals.

These mammals were beginning to be more and more like our modern species, or kinds, of animals. Many of them lived only during the first part of the age and then became extinct. Others have continued to live into the present, but have changed a great deal in doing so.

The mammals were of many sizes. Some grew to a huge size, larger than any living elephant. Some of the largest mammals that we know lived during the early part of the age. But there were also tiny and middle-sized mammals.

Mammals were of many kinds. Some mammals walked on five toes, others walked on only four or three. One group of these animals had claws. Some also had long gnawing teeth. Some ate grasses and other small plants. Some roamed in herds. Others lived alone and ate the vegetable-eating animals. But let us look at some of these animals and see how they were alike and how they differed from animals of the same families living today.

One of the very earliest kinds of horses that scientists know about was not like a modern horse. It had four toes on each front foot and three toes on each hind foot. Its body was long, and its legs were rather short. It was about as large as a good-sized dog or fox.

How were *Eohippus* and a modern horse alike? How were they different?

Should you like to know the name that scientists gave this early horse? It is *Eohippus*. *Eohippus* first lived in the forests, and he escaped from other animals by running. His legs were quite well adapted for quick starting and rapid running. The picture on page 193 shows *Eohippus* and a modern horse.

As time went on some of the horses became larger. Later on they had only one large toe, or hoof, on each foot. The legs of the later horses were more slender and could move with even greater speed than the legs of earlier horses. Perhaps only the horses that had developed more slender legs had escaped their enemies. They escaped by using this speed. By this time many of the forests had slowly changed to grassy plains, and the horse needed to run rapidly in order to escape. Those animals that could not run rapidly were caught and used as food by other animals, and their kind became extinct.

During the early part of the Age of Mammals horses ran wild on the plains of North America, but at some time something happened that caused them to disappear from North America. At that same time, however, there were wild horses in Europe and Asia. It was not until the Spaniards brought horses with them into southern United States and Mexico, and later left them to run loose, that wild horses again trampled the plains of North America. They increased in number. Then they were caught, tamed, and used by men. At present there is only one kind of truly wild horse in the world. That is the small Asiatic wild horse. There are not many of them to be found.

The word *rhinoceros* means "nose-horn," which is a very good name for the rhinoceros we know today. But it did not fit some of the earliest of these animals. Although there were

some that had horns with which they protected themselves, most of them did not have horns. They had to protect themselves by other means.

The rhinoceros is a relative of the horse. At first it was small and slender and much more like a horse than the rhinoceros you know. But later its legs became shorter, and its body clumsy and awkward. One of the early rhinoceroses was about the size of a fox or a little larger. It was light and slender and could run from its enemies. Another kind was tall enough to eat twigs sixteen feet above the ground. Rhinoceroses roamed over North America later in the Age of Mammals and in the beginning of the Ice Age. Rhinoceroses and horses belong to the family of single-hoofed animals.

The elephants were not at all like the giants of the jungle

This is a mammoth that lived during the last Ice Age

© F. M. N. H. From a painting by Charles R. Knight

This is an elephant that lives today. Compare him and his way of living with his relative, the mamm

that you know. They were small, with very short trunks and tusks. In the first part of the Age of Mammals they were not so heavy as elephants are today and could reach the ground with their mouths; they did not need long trunks. But in the time since then the trunks have become longer and longer, and now elephants eat from the ground while scarcely bending their heads, and their tusks have become so large that some tusks weigh two hundred pounds apiece.

The earliest elephants are thought to have lived first in northern Africa. They were about the size of a pig and lived near the swamps. Later they lived in North America, and in the Ice Age some of the largest elephants ever known lived in the ice and snow. These were the mammoths and mastodons.

You have seen camels in a circus, but you have never seen them wild in the country, as you have seen rabbits or squirrels. Yet at one time there were camels running wild in many parts of North America, South America, and much of Europe and Asia. But they are thought to have lived first in North America. There may have been camels right where you are living now.

Scientists are not sure whether these early camels had a hump. Camels' humps do not have bones in them. Therefore scientists cannot tell about the humps from the animals' fossil bones. There were large camels, standing seven or eight feet high. They were somewhat like the camels that are found in Asia today, but they were also like the camels in South America which you know as llamas.

A peculiar animal of the early part of the Age of Mammals was the sloth. The largest of the sloths was the giant sloth, which was nearly as large as an elephant is today. The back part of its body was very large and heavy, and it had a heavy tail; the front part and legs were much lighter. It could lift its front legs much as a bear does. In this position the animal fed upon the leaves of trees. When branches were a little high, it pulled them down with its claws so that it could reach the leaves. It also grazed in the open country. The sloths were very awkward and walked on the outer edges of their feet, as you can see in the picture on page 198.

These animals were among those which have become extinct. Out in the open country the sloths were probably easily seen by their enemies, the wolves and tigers. Although they had strong front limbs and stout claws which they used in fighting, they probably did not succeed in many battles against other animals. This may have been the reason why they became extinct.

Even though the ground sloth disappeared, its smaller relative, the tree sloth, succeeded in living and may now be found in the dense forests of Central and South America. These sloths do not find their food on the ground, but live on the leaves of trees. They hang upside down by their feet on branches of trees and have been known to sleep in this position. Sloths have a shaggy coat of hair. Unlike their giant ancestors these sloths have almost no tail at all. Some have two toes on each foot and are called two-toed sloths. Others have three toes on each foot and are called three-toed sloths. A three-toed sloth is shown in the picture on page 199.

The very earliest mammals lived on insects; then in later years, as larger mammals developed, many of them began little by little to eat other small animals as well as insects. They were the first of the flesh-eating mammals. The fiercest of these mammals were those of the dog and cat families.

This giant sloth has become extinct

© F. M. N. H. From a painting by Charles R. Knight

New York Zoological Society

Compare this sloth, which lives today, with its early relative

Wolves, foxes, and bears belonged to the dog family. Lions and tigers were members of the cat family. All these animals lived almost entirely upon the flesh of others.

The saber-toothed tiger, one of the fiercest of the flesh-eating animals, also belonged to the cat family. You probably have noticed the two sharp, long teeth on the upper jaw of a cat. The saber-toothed tiger had two very long teeth.

It was probably not a swift-moving animal. About the size of the African lion, it depended upon killing large slow-moving mammals. With its strong front legs and claws it attacked and held an animal, cutting it with the great daggerlike teeth. This tiger has been extinct for many years.

Anteaters were another kind of flesh-eating animal. They tore open the hills made by ants and fed upon them. These anteaters were ancestors of the ones which live today.

Los Angeles Museum of History, Science, and A

What are the birds and saber-toothed tigers waiting for?

Can the two sloths help the third on

Armadillos, whose heads and bodies were protected by an armor of small, bony plates, were also among the early mammals. They were so well protected that they have lived on through the years to the present day.

Some of the early mammals began to spend all or a great deal of their time in seas or oceans. Seals, sea lions, and walruses lived by feeding upon the fishes and shellfishes they found in the sea.

FOSSILS OF ANIMALS IN THE LA BREA PITS

In a small area in California, pits have been found that are filled with tar and oil. As you look at these pits, you see nothing but a dirty, black surface with bubbles of gases coming up through the tar. But down underneath the surface the pits hold an interesting story.

rom a painting by Charles R. Knight
sloth is held by the tar in one of the La Brea Pits.

What story does this picture tell?

If a small stone rolls onto the mass, it makes a dent in the tar. As you watch, you notice that the stone starts sinking slowly into the black substance. It sinks slowly, but steadily, until the tar folds over it, and it is gone.

The stone was not alive and was not harmed. But living things in times past have been harmed in the tar. From tar pits in Los Angeles, called the La Brea Pits, men read the following story.

Animals running upon the prairie in ages long ago did not see the pits in time to run around them, or they did not know what great danger the pits held for them. They ran out on top of the tar, and just as a stone sinks, these heavier animals, whose feet were held fast by the tar, began to sink. They had no means of escape. They sank slowly.

Animals caught in this tar trap howled or cried as they sank. Perhaps their cries brought animals of their own kind

to help them. A mother, hurrying to help her young, might easily be caught in the tar, and she herself be unable to get out. When an animal that lived upon other animals heard the cries, it ran to the pit. If the helpless animal was close enough to firm ground, the second animal ate it. Very often, however, the second animal, not realizing the danger, was itself caught in the tar and died with the creature it wished to eat. For centuries the tar held just such a fate for many animals.

A number of years ago men took tar out of these pits to sell. It was at this time that bones of animals of long ago were brought to the surface. For a while little attention was given to the bones, but scientists later collected many of them and noticed that they were the bones of kinds of animals which are not living today.

Plant-eating animals whose bones have been dug out of the pits are horses, tapirs, bison, elephants, mastodons, and deer. Some of these kinds are now extinct, and some kinds that are still living cannot be found now in North America. There were many more kinds of flesh-eating animals than of those that ate plants. Many skeletons of wolves, lions, bears, and saber-toothed tigers have been found. These animals, which came to attack victims of the tar, also sank within its sticky depths. It is in this way that the La Brea Pits tell us what happened in the past to kinds of animals which no longer live upon the earth.

THINGS TO THINK ABOUT

1. The age in which you are living is the Age of Mammals. It has been a very short period compared with the earlier ages.

2. At the same time that some animals began to become more like modern animals, great changes in the earth's surface were

taking place. The Alps, Apennines, Himalayas, and Carpathian Mountains were being folded upward for the first time. The Rocky Mountains, which had been raised and then worn down, were again lifted to a great height. This was the last time they were folded. They are being worn down in the present age, but they are still very high mountains. The Sierra Nevada and the Cascade Range also were folded at this time. This was the age when volcanic lava spread over the Columbia and Snake River valleys, and in the Yellowstone Park region in western United States.

3. Birds and mammals were the last known groups of animals to develop. New animals in each group have appeared since, but not an entirely new group. Slowly the animals of each group have changed into modern kinds.

4. Why do you think our plants and animals of today are more like those described here than like those you read about earlier?

THINGS TO DO

1. Watch a horse when he is startled. See how rapidly he can jump to one side or start running. He is protected by this rapid movement.

2. Look up the meaning of *saber.* Then tell how you think the saber-toothed tiger earned its name. Some men thing that the teeth of this tiger finally became so long that they hindered the animal in eating and catching food. The long teeth may have caused this animal to become extinct.

3. Visit a museum, if there is one near you, and see how many skeletons of extinct animals you can find. Where did they live? How do they compare with more modern kinds? Can you see any reason why they may have become extinct?

The Last Ice Age

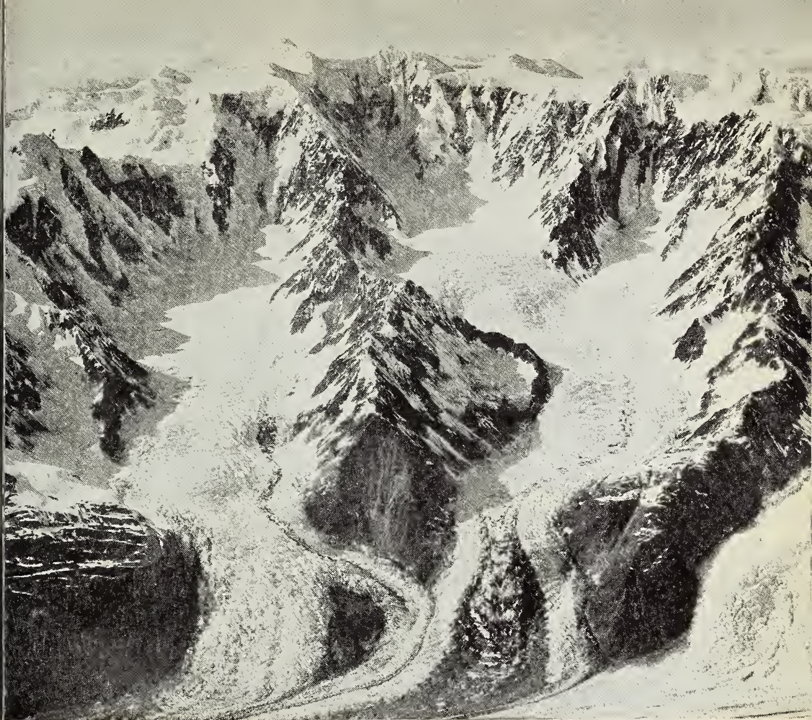
GLACIERS OF THE PAST

The earth was filled with living things. Modern animals and plants grew, birds sang, and flowers blossomed. But again the climate began to change very slowly. The warm, moist air became cooler. At first it probably cooled only a few degrees in hundreds of years. Then, in the Far North, as centuries passed, warm days became chilly, and chilly days became cold. The cold slowly crept down into what is now Canada, the northern part of the United States, and northern Europe.

On the tops of mountains it was very cold. The rain changed to snow and covered the sides of the mountains. At first the snow melted and ran down into the valleys and was carried away by the rivers. But as time went on, it became so cold that not all the snow that fell in the winter could melt in the summer. Layers of snow next to the ground were packed hard. Snow that melted froze again, and the whole mass was pressed into ice. Snow fell winter after winter and remained, adding to the growing sheet of ice.

As the snow became packed and frozen near the tops of mountains, it formed glaciers; then as more snow collected on top of the glaciers, the weight of the snow, added to the weight of the glaciers, caused them to slip down the mountainsides, as they are doing in the picture on page 205. The glaciers really flowed downhill, just as water flows, because they were pulled by gravity. Since they were solid ice, they could not flow so fast as water. They flowed very, very slowly and moved only a few inches in a long time.

After thousands of years the climate had become so cold and so much snow had fallen that glaciers became larger and



Bradford Washburn

hese glaciers are moving down the sides of the mountains and are joining together

larger. They spread out and joined together. Then they traveled in great ice sheets, flowing down from the Far North. The ice sheets became larger and pushed on southward. Snow continued to fall until the ice sheets all formed one great ice sheet, in some places a mile or more deep. One such ice sheet once covered almost all of northern Europe. Another covered many parts of Canada and the northern parts of the United States.

Sheets of ice were not new upon the earth. They had

covered some parts of the world in earlier times. There were at least three other ice ages when glaciers covered enough of some continents to form great ice sheets. The first Ice Age came millions and millions of years ago, at a very early time, probably before life had started upon the earth. The second Ice Age came about the time life had a good start upon the earth, possibly when there were a few kinds of shellfish, worms, and seaweeds. This was not a very great Ice Age and did not last so long as the others.

A third known Ice Age came when the earth had become covered with plants and animals. It came in the time following the Coal Age, when there were trees, amphibians, and some reptiles. This was probably the greatest Ice Age of all times. It occurred mostly in the Southern Hemisphere, and covered large areas in Africa, South America, and Australia, as well as in Asia. It was so cold that the ice was present even on low ground in the tropics in South America, Africa, and Asia. There also may have been glaciers in some parts of North America and Europe.

The fourth and last great Ice Age probably was caused in much the same way as the others. There must have been a more or less general cooling over all the earth, but the ice sheets themselves formed on the continents of Europe and North America. The map on page 207 shows that there was little ice on the other continents except on the highest mountains and in Antarctica and Patagonia. The last two ice ages were the greatest, so far as scientists can tell.

We do not know what caused the different ice ages. There are many theories of what might have caused them, but none of them have proved entirely satisfactory. Probably a number of things caused them. Were it not for the heat the earth receives from the sun, it would always have low

The white parts show which parts of the earth were covered with ice sometime during the last Ice Age

temperatures. If the earth were just a few degrees colder all the time, it would be too cold for life as we know it. Therefore, whatever caused the ice ages, it must have been something which cut off some of the heat from the sun or caused less heat to be held by the earth.

Air which has great amounts of water vapor and carbon dioxide holds more heat than air with less amounts. If the air at the time of the ice ages had less water vapor and carbon dioxide, it held less heat, and the earth therefore became cooler.

Sun spots may have caused the earth to receive less heat. Great clouds of dust and gases between the earth and the sun may have held some of the sun's heat and made the earth colder. The cooling may have been caused by several things.

After the Northern Hemisphere had been cold for thousands of years, during the first part of the last great Ice Age, the climate grew warmer. The southern edge of the ice melted back farther and farther each year. It probably melted back as slowly as or more slowly than it had moved forward. As it melted, the edge crept back to the north, taking thousands of years to do so.

But even then the climate did not remain mild. Again and again it cooled, until, as some scientists believe, at least four great ice sheets formed during the last Ice Age. Four times the climate became warmer and melted them back. Once or twice it may have become warm enough to melt the ice sheets completely.

As each ice sheet formed, many plants and animals were slowly driven ahead of it. Some, however, remained in the north and succeeded in living on the hills and mountaintops with glaciers everywhere below them. Some were driven as far south as South America. Many could not endure the changes and became extinct.

The woolly mammoth, the reindeer, and the musk ox lived nearest the border of the ice. They grazed upon the moss and grass in what are now New Jersey, Nebraska, and other states along the border. The walrus lived as far south in the United States as Georgia. Those animals that could not endure so much cold moved far to the south.

Then as each ice sheet melted back, year after year plants and animals began to migrate farther north. This they did for the thousands of years that the ice was melting back. Therefore soon after the ice had left, life could be found farther and farther north.

The periods between ice sheets were so long that many kinds of trees and other plants grew far into the north.

Fossils are found which show that locust, papaw, and Osage orange trees grew as far north as Toronto, Canada. That is farther north than they grow today.

Besides affecting growth of plants and animals, the glaciers changed the country. As they moved down mountains and through valleys, they pushed gravel, rocks, and earth ahead of them. At times the ice sheet was so thick and heavy that it pushed off the tops of hills and made them round. All this soil and rock the ice carried with it. Then, as the

ll of these rocks, even those of which the fence is made, were left by glaciers

Sawders

ice retreated, it left this soil and rock just where it melted, forming hills and ridges. Many signs, for instance the rocks in the picture on page 209, show how far south the great ice sheets went.

Ice sheets changed the surface of the country in another way also. They helped to form many lakes and sometimes changed the courses of rivers. Sometimes their great weight caused them to dig out holes in the ground as they moved along. At other times they unloaded their sediment in a valley, blocking a stream or river in the valley, or making it impossible for water to pass through. As the ice melted, the water gathered in the holes or valleys and formed lakes.

Some of the lakes did not receive enough water to continue, and they became dry. However, water from slopes around some of the lakes has continued to flow into them, and many of the present-day lakes started in that Age of Ice.

Much of the world had been cold and quiet during the last Ice Age. An icy calm had covered a large part of the earth. But after the ice sheets were melted, birds returned from the south and filled the woods with cheering songs. The green grasses became dotted with the beauty of flowers. The earth grew to be more nearly as we know it.

Some scientists think that man first lived upon the earth during the last Ice Age. It was in one of the warmer periods between times of great ice sheets or perhaps just before the Ice Age that man may have begun to live. He lived upon animals or the plants about him, gathering fruits and berries, or seeds and roots. His life was very different from any life you know. He had no tools with which to farm, or to build his home. He had no tame animals to do his work, no flocks upon which to feed. His living depended upon the food he could find.

Food was only one of the big problems. Another great task was to protect himself from other animals. He had no weapons. He had to depend upon his higher intelligence and his strength to fight his battle against the other animals.

When the climate again became colder and ice sheets came down from the north, man had another problem to face. He could not live as he had during the warmer times. He had to seek shelter from the snows and cold. In doing so he began to live in caves or other simple homes. He began to use animal skins for clothing, and to gather and store food. Perhaps some men migrated with the other animals. In some way or another man has succeeded in living into the present time.

WE SHOULD NOT FEAR GLACIERS OF THE FUTURE

There are reasons for thinking that the last Ice Age has not yet completely departed. Many people believe we are now living during one of the ages between great ice sheets. This may be true. You know that ice still covers Antarctica and much of Greenland and other countries to the north. There are glaciers today in some high mountains in the temperate zones. Scientists know also that at least some ages between times of great ice sheets were very much warmer than our climate is today. This is shown by fossils of plants which grew much farther north than their kinds do today. At some time the earth may again grow colder and colder until another ice sheet is formed. But the last Ice Age may be over. If so the climate may grow warmer until life can live upon all parts of the earth.

Whichever happens, people living today cannot be greatly affected by it. Scientists have kept a record of temperatures

on the surface of the earth for many years. So far they have not been able to find much change in average temperatures. Some summers are very hot; some winters are very cold. But cooler summers and warmer winters have followed, to make the average temperature about the same.

The periods between ice sheets have been thousands of years in length. Such changes do not take place rapidly. They occur very, very slowly. If another ice sheet does come later, thousands of years of time will probably first pass in this "between" age. It took a long, long time for great changes to take place in the past. There is every reason to believe that it will take a long, long time for great changes to take place in the future.

THINGS TO THINK ABOUT

1. Explain why some kinds of animals that once roamed over North America and Europe in great numbers became extinct.

2. It is thought that about two million square miles of Europe and four million square miles of North America were covered with ice at some time during the last Ice Age. Much of Greenland and all of Antarctica are still covered. All in all, at one time or another in the last Ice Age, ice covered about twelve million square miles of surface, or about one fifth the total surface of the earth.

3. If one cubic foot of ice weighs about 60 pounds, how much would a column of ice one mile high above one square foot of area weigh?

4. Minor earthquakes in Ohio are thought by some to be caused as a result of the last Ice Age. During this Ice Age there was great pressure upon the surface beneath the ice. In Ohio the movements may be caused by the earth recovering from this enormous pressure of the ice.

5. How did ice sheets and glaciers affect the country over which they passed?

THINGS TO DO

1. Imagine yourself an early man during the last Ice Age and write a story about the life then.

2. Tell what you think the plants, birds, mammals, insects, amphibians and other kinds of animals did during the last Ice Age.

3. See if you can find how fast present-day glaciers flow.

4. If you live in a region once covered by an ice sheet, tell how it affected your region. Did it affect your way of living?

5. The remaining four feet of your line covers all that occurred in the Age of Mammals. Think of all the changes that happened in that time. Compare the length of this age with that of other ages. It has been a very short time in comparison, yet the Age of Mammals has been millions of years in length.

VIII

Man's Conquests in the Plant and Animal World

MAN'S INTELLIGENCE IS THE MIGHTIEST WEAPON OF ALL

MAN RAISES HIS OWN PLANTS AND ANIMALS

MAN MAKES GREAT CHANGES IN THE PLANT AND ANIMAL WORLD

PLANTS AND ANIMALS NEED EACH OTHER

MAN UPSETS THE BALANCE AMONG LIVING THINGS

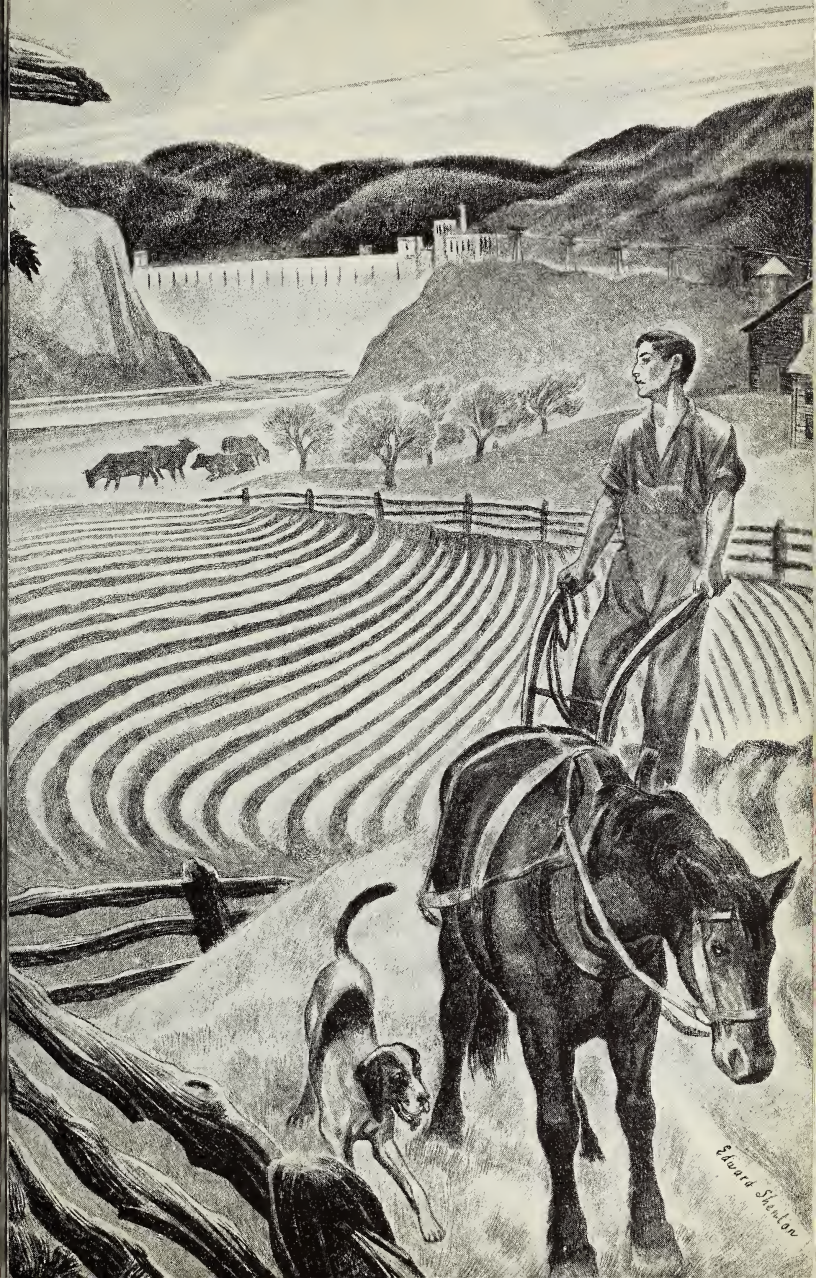
THOUSANDS of years ago men probably lived much like animals. They searched for the plants that were good to eat. They killed animals with their hands when they were in danger or hungry for meat. And at night trees or caves were used for shelter. Other animals had been living like this for many centuries.

Human beings probably would not have continued to live on the earth very long if they had not made a very important discovery. They discovered that they had minds, which they could use to protect themselves from wild animals. Most animals have very good ways of protecting themselves. Foxes have keen, or sharp, eyes and a keen sense of smell. Deer can run swiftly. Lions and tigers have powerful jaws and leg muscles. Ancient men learned that their minds were mightier weapons than the keener, or sharper, senses, swifter legs, and more powerful jaws of other animals.

When people were living in trees and caves, someone discovered that he could kill the most powerful animal by striking it with a rock or a club. When men learned that they could use weapons to protect themselves, they did not spend so much time hiding and running from their enemies. They had more time to learn new things about their world.

Men's minds have made it possible for them to do many things that other animals cannot do. Many animals have lived on the earth for a longer time than men have, but these animals are living in the same way their ancestors lived. Human beings have been able to discover and invent much easier ways to get the things they need in order to live.

In this story you will read about how men are learning to live in their plant and animal world.


Edward Shenton

Man's Intelligence Is the Mightiest Weapon of All

It is as natural for some animals to protect themselves when they are in danger as it is for you to wink when someone points his finger too near your eye. You cannot help winking, and other animals cannot help playing "dead," running, flying, swimming, or hiding when they are in danger. Most animals protect themselves without thinking about it. We are the only animals that are able to think of ways to protect ourselves. Our minds are mightier weapons than the powerful running legs of the deer, the sharp teeth of the tiger, or the wings of the eagle.

Because human beings have better minds than other animals, they have been able to discover and invent many things during the short time they have lived on the earth.

A very long time ago language was invented. Language is used to talk about the things we learn and think.

Language has made it possible for you to learn in a few years many of the things that it has taken man thousands and thousands of years to learn. Other animals do not know any more than their ever-so-great grandparents did in the past.

People probably had not lived on the earth very long before they learned to use the things around them to protect themselves from other animals.

Cave men learned to use sticks and stones for weapons. Sticks were used for spear handles and bows. Flint was cut into spearheads and arrowheads. As the years passed, these weapons were improved. These discoveries helped cave men to become very skillful hunters and fishermen. Meat became more plentiful. A successful hunt was now a result of skill

Larger animals could be killed with spears

rather than luck. With better weapons these early men could kill large game. The fur of larger animals could be used for bedding, clothing, and shelter.

No one knows how long early people lived in cave homes before they learned how to build a fire. Scientists believe that fires have been used for many thousands of years. Scientists believe this because they have found ashes from fires that were built a very long time ago. After the discoveries of tools and fire, men began to migrate, or move, to the colder parts of the world.

THINGS TO THINK ABOUT

1. What are some of the things that cats, dogs, and birds are ready to do when they are only a few weeks old? The lion brings back its food alive and lets its young play with it before eating it. Lions take their young with them on the hunt. Animals teach their young many things.

2. What are some of the things that you knew how to do when you were born? People do fewer things without thinking than most animals. Ants do a great many things without thinking.

THINGS TO DO

Try to make a fire as early men did. They made fire in several different ways. One way was by rubbing two sticks together. Why were these men so careful to keep their fires burning?

Later, men learned an easier way to make a fire. They struck two pieces of flint together. They let the spark from the flint fall on dry grasses, leaves, and small bits of wood. Try to make a fire in this way.

Still later, men learned that it was much easier to make a fire by using steel and flint. Devices for lighting cigarettes and cigars, called lighters, have steel and flint in them. Examine one of these lighters and try to explain how it works.

When people use matches, they usually strike two things together in order to start a fire.

Man Raises His Own Plants and Animals

The people who lived on the earth a very long time ago did not know that they could raise their own plants and animals. Someone had to discover that this could be done.

After thousands of years of wandering, a much easier way was found to get the animals needed for food and clothing. Men learned to domesticate animals; that is, to tame wild animals and raise young from them.

Very little is known about how men learned that they could raise animals. But it is known that the discovery was made a very long time ago. Perhaps, on a game hunt, a man found an animal that he did not want to kill because he liked it so much. He may have kept this animal as a pet. Possibly, one day, after many unsuccessful hunts, his hunger forced him to kill the animal for food. This may have made him realize that he could keep animals and use them for food.

This man was the first herdsman. Other men heard about the discovery, and they also began to keep animals. These herdsmen learned that there were both male and female animals, and that if they kept both kinds they could raise young. They also learned other things about their herds and flocks.

Cattle, horses, sheep, and poultry eat plants. Since these animals live together in herds and flocks, they can be pastured, or fed by grazing. This is the reason why plant-eating animals were domesticated rather than meat-eating animals.

For many years herdsmen wandered with their herds and flocks until someone discovered that he could raise the plants he needed for himself and his family. How proud the first family that raised its own grains and vegetables must have been!

But you must not imagine that these discoveries were made in a few years. It took a very long time for such changes to take place. There were a great many things to learn about the soil and the plants growing in the soil. Hand tools had to be invented to be used in planting and harvesting the crops. During the many hundreds of years that passed, some of these things were learned.

After men had learned how to raise the food they needed, they could settle on a piece of land large enough to raise their food. On this land they could live all the year round. Living was no longer so difficult and dangerous as it was during the time of the tree dwellers and the cave dwellers. Even in these very ancient times human beings were discovering an easier way to earn their living.

THINGS TO THINK ABOUT

1. Grains that once grew wild on the plains of Asia have been carried to Europe, North America, South America, Australia, and many of the islands in the Pacific and Atlantic oceans.

2. India is known for its rubber trees; yet rubber trees are not native plants of India. Men brought them there.

3. Horses are so common in North America that we usually think they have always been here. Wild horses that used to gallop across the plains of North America are descended, or came from, native horses of Asia.

4. Cats have been brought to many countries of the world. They first came from Egypt.

5. Most of the food crops and domesticated animals raised in North America have been brought from other continents.

Can you see why the ancient farmers' fields were small?

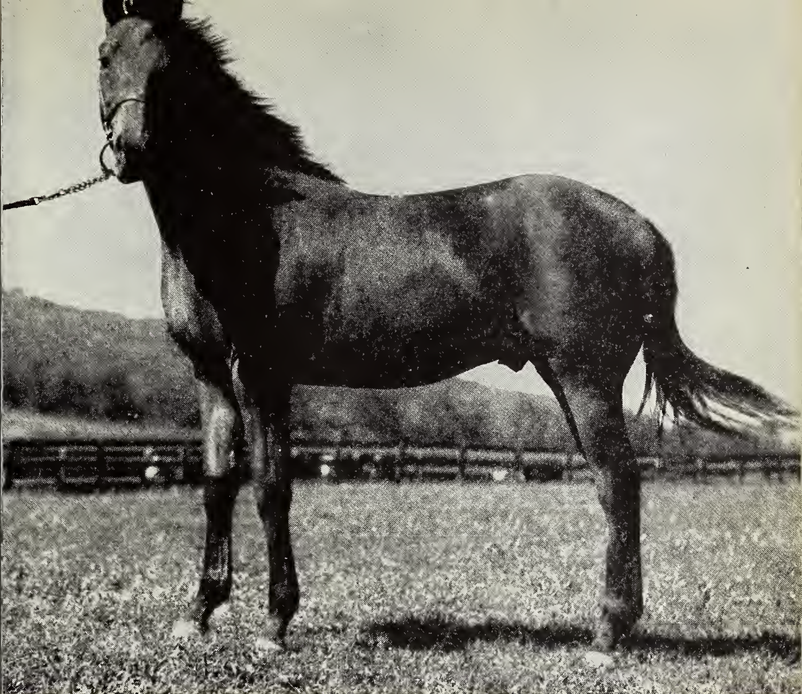
Man Makes Great Changes in the Plant and Animal World

Since the time of the early shepherds and farmers, men have been discovering ways to change living things so that they will be more useful to us.

They have learned that strong, healthy animals are more apt to have young that will grow into sturdy adults. That is why the small, weak animals in the farmers' herds and flocks are killed and used for food. Because only the best domesticated animals have been allowed to produce young, these animals grow much larger than they did in the past.

Some horses are raised to do trucking and heavy farm work

Galloway



Roberts

Race horses are selected for their speed

Fruits and grains have been greatly improved. Only the seeds of the most delicious fruits and grains are planted during the season in which they will grow the best. These seeds are planted a certain distance apart. This is done in order that the seeds may have room enough to get the light, heat, water, and minerals they need to grow. When wind and animals scatter seeds, only a few of these seeds fall in a place where they can get the things they need. Because only the best seeds are chosen for planting, domesticated plants produce both more and larger fruits and grains than they did when they grew wild.

Yearbook of Agriculture, 1937

A new kind of strawberry plant is being made
by applying the pollen from a different kind of strawberry blosso

As the centuries passed, men also learned to choose those plants and animals that were better for certain purposes than for others. Some kinds of fruits and grains grow better in colder climates. Certain kinds of sheep grow better grades of wool. Some cattle give more milk than others, and some cattle give richer milk than others.

You may have read about men who made new kinds of plants by taking the pollen from one plant and placing it on the pistil, or seed-producing part, of another plant in the same family. New kinds of citrus fruits, such as oranges, lemons, and grapefruit, grains, and vegetables have been made in this way.

THINGS TO THINK ABOUT

1. Think of some of the ways in which animals help to scatter seeds. Why is it important that seeds should be scattered?

2. Grains have been so changed by men that it is very difficult for scientists to find the kind of plant from which they first came.

3. One spring a farmer noticed dozens of tiny chestnut trees coming through the soil in his field. The field was not far from the chestnut trees that shaded his lawn. What animal might have buried the chestnuts in this field?

4. Why are there so many fruit trees along roadsides? What animals probably dropped the seeds from which these trees grew?

5. Many animals help to plant fruit trees and shrubs, because only the juices of fruits and berries are used as food. The seeds are dropped.

6. The seeds of food crops have multiplied, or increased in number, many thousands of times since men learned to care for them.

THINGS TO DO

1. Visit a farm and ask the farmer how he decides which animals should be kept to raise young. If you cannot visit a farm, perhaps you can visit a place where dogs are raised or a zoo. Ask the people in charge how they select the animals that should be allowed to raise young.

2. In the fall find a dandelion that has gone to seed or a milkweed pod. Carry the dandelion or the milkweed pod to a field that is some distance from a lawn or cultivated field. Blow against the threads that are fastened to the seeds. Notice how many seeds fall in places where it is possible for them to grow. Probably only a very few ever fall in a place where the conditions are good for growth.

Plants make all the food there is in the world. Animals get

eir food from plants or from animals that eat plants

Animals carry pollen from one plant to another

Plants and Animals Need Each Other

It has taken people many thousands of years to learn that most plants and animals cannot live without each other.

Plants make almost all the food there is in the world. Animals get their food from plants or from animals that eat the plants. Some animals, such as cows, sheep, and hogs, live upon grasses or grains. We eat the meat of these animals. If there were no grasses or grains, the animals that live upon plants would die. The animals that eat the plant-eating animals would also die. If anything happened to all the plants in the world, it would not be long before all the animals would either be eaten or die from starvation.

Plants and animals depend upon each other for the gases they must have in order to live. Green plants separate the oxygen that is a part of carbon dioxide and of water. Green plants use some of this oxygen in food-making. The oxygen that is left goes into the air. Food must be combined with oxygen before our bodies can use it. As oxygen combines with our food, some of the carbon, an element which is in the food, unites, or combines, with oxygen and forms carbon dioxide. This carbon dioxide goes into the air. The leaves of green plants need carbon dioxide to make their food.

Some flowering plants need animals to help them to produce seeds that will grow into plants. A seed that will grow into a plant is called a fertile seed. A fertile seed must receive pollen from the male parts of the plant. Some plants have both the male and female parts on the same plant. Most of these plants can use their own pollen to make their seeds fertile. But some plants cannot use the pollen from their own blossoms. Fruitgrowers have learned that McIntosh apple blossoms cannot use their own pollen. The McIntosh apple blossoms depend upon honeybees to carry pollen from some other kind of apple blossom.

There are male and female pussy-willow bushes. If this kind of willow is to produce fertile seeds, the wind must blow pollen from the male bush to the blossoms on the female bush. Plants cannot move about to find pollen to make their seeds fertile. They must depend upon the wind, birds, or insects to carry the pollen from one plant to another.

There is a large group of plants called fungi that help to keep the earth clean. Tiny rod-shaped, corkscrewlike, oval-shaped, or threadlike plants called bacteria, yeasts, and molds are different kinds of fungi. Fungi feed upon dead plants and animals. If it were not for fungi nothing would decay.

As fungi feed upon the dead plant and animal material, they give off carbon dioxide into the air. Fungi change dead plant and animal materials into carbon dioxide and mineral salts, which are like table salt. Carbon dioxide and salts help to make richer soil. Green plants use this carbon dioxide and the salts in food-making.

Every year that passes, men are discovering more ways in which plants and animals are important to each other.

THINGS TO THINK ABOUT

1. Cattle are very important animals to man. In what ways do cattle depend upon man and other living things? What do cattle do for these living things? Why does the farmer have to be careful not to keep too many cattle?

2. If dead plants and animals did not decay, the earth would soon become so crowded with dead things that there would not be enough room for living things.

THINGS TO DO

1. Get some gelatin powder from your home or a grocery store and make some gelatin. Cover the bottom of two dishes with this substance. When the gelatin is cooled, it should be as thick as jelly. Rub your finger over the top of the gelatin in one of the dishes. Cover both dishes and let them stand for a few days. Watch the results. Where did the bacteria that must have been on your fingers come from?

2. Look at some black mold through a hand lens or microscope. The little white threads take in the plant's food. The round black balls contain millions of spores. Spores are like tiny seeds. Some of these spores may grow into mold plants.

3. Look for different kinds of molds. You will find them on bread, cheese, fruit, and other kinds of foods. There are many, many different kinds of molds. Why are molds useful?

Man Upsets the Balance among Living Things

Billions, or thousands of millions, of acres of land have been greatly changed since men began to raise their own food. Forests have been cut. Heavily sodded ground has been plowed. Swamps that might someday have become coal beds have been drained. On these lands food crops were planted, animals were grazed, and homes were built.

These billions of acres of farming land were once the homes or feeding grounds of many different kinds of plants and animals. Some of these plants and animals were destroyed. The larger animals were easily driven away, but the insects were more difficult for men to control.

It does not seem possible that we should be bothered by insects. They are such small animals!

It is numbers, not size, that counts this time.

Insects can reproduce, or have, a great many young in a year. Some insects may lay as many as three thousand eggs in a day. In a few days these eggs hatch into young insects. These young insects have enormous appetites. They will eat their weight in food every day while they are growing. In a few more days they become adults and are ready to lay more eggs. It takes only from eight to fourteen days for an egg of a housefly to change into an adult housefly.

A pair of houseflies reproduce rapidly. At the end of a year one pair of houseflies could have over five billion descendants, or young, if they all lived and reproduced. Think how many that would be, and all these descendants from one pair of houseflies! If these flies were lined up, one behind the other, they would make a line about 25,000 miles long, or as far as around the earth at the equator. That number would be over

twice as many flies as there are people in the world. If one pair of flies could have so many descendants, how many would there be in the world? How many flies might you prevent from reproducing if you killed adult flies before they laid their eggs? Of course all of the five billion descendants from each pair of flies cannot live, because there are other animals to eat them.

For thousands of years farmers have lived in fear of the black clouds of grasshoppers that swept down upon their fields. No wonder people thought that the gods sent these insects as a punishment. For these grasshoppers seemed to have dropped down from nowhere. Men were powerless. They knew of no way to destroy these insects. Centuries passed before it was learned that grasshoppers lay their eggs in hard dry ground in the fall of the year. Some farmers destroy thousands of grasshopper eggs by plowing their fields in the fall.

Because other insects were also becoming more numerous, people began to wonder why the insects were multiplying faster than larger animals. There were several reasons for this.

Insects have more food than they had in the past. They feed upon the millions of acres of land on which farmers plant food crops. When animals have more food, more of them can grow up and produce young. This is one way in which men have upset the balance between the green plants and the insects.

Insects lay many more eggs than larger animals. Animals that lay many eggs usually have many enemies that eat them. In the past insects had many more enemies.

Many birds eat insects. During the spring and the summer the robins are busy hunting caterpillars, young insects called

American Museum of Natural History

the end of one year, a pair of houseflies could have over five billion descendants

grubs that feed on the roots of plants, and adult insects. Small birds, such as chickadees and warblers, dart over the branches of the trees destroying adult insects and their young.

From early morning until late at night, woodpeckers tap, tap, tap on the trunks of trees, hunting for insect food. Birds eat insects in all the stages of their growth. They eat the eggs laid by the female moth and the tiny worms, or larvae, that hatch from the eggs. They also eat the young insects in the pupal stages when they are changing from larvae into adult insects. And they eat the insects after they have come out of the hard pupa skin as adults. Birds help to keep down the number of insects, that would soon cover the earth if they or some other animals did not eat them.

As lands were cleared for farming, many of the larger animals,
which helped to keep other living things in check, were destroy

Birds are not so plentiful today as they used to be. In the early history of America birds were so plentiful that they were shot and used for food. Many other animals that helped to keep insects in check were also killed for food.

As the people in North America moved farther westward, they disturbed the freedom of many animals. Animals were killed by the hundreds. When towns and cities were built, many of the places that animals had used for homes were destroyed. For this reason fewer birds and larger animals are growing up and producing young than in the past. Animals now have fewer places where they can raise their young in safety. Swamps that used to make safe homes and feeding grounds for many animals have been drained. These are only some of the ways in which the balance between plants and insects has been upset.

MAN BRINGS IN PLANTS AND ANIMALS FROM OTHER REGIONS

As food and lumber were shipped to different parts of the earth, plants and animals were shipped along with them without anyone's knowing that the plants and animals were there. Since these plants and animals had never lived in the places where they were brought, there was no living thing that would use them for food. Insects multiply rapidly in a country where there are no animals to eat them. When animals become too numerous, they are apt to do a great deal of damage to our food crops.

The Hessian fly probably does more damage to the wheat crops in America than any other insect. The Hessian fly was brought to America in a shipload of hay that was unloaded on Long Island, New York, when the Hessian troops landed during the Revolutionary War.

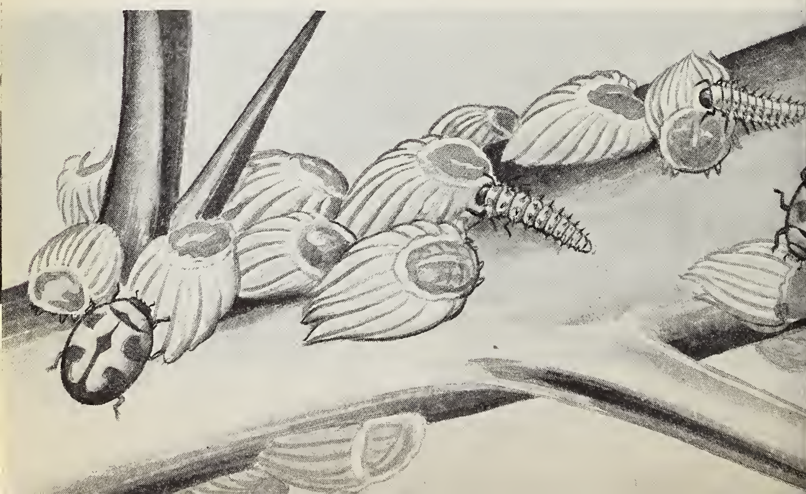
The cottony-cushion scale was brought into California. It did a great deal of damage to the fruit trees before some animal was discovered that could keep it in check. Australian ladybird beetles will eat these scale insects. Men had to import Australian ladybird beetles to help them to control the cottony-cushion scale. The Australian ladybird beetles ate so many of these scale insects that they do very little damage now.

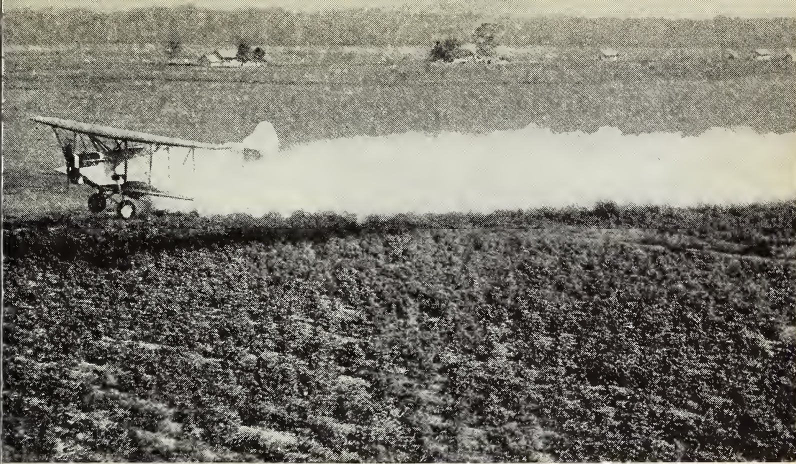
Mediterranean fruit flies, gypsy moths, European cornborers, and Mexican boll weevils are only a few of the many injurious insects that have been brought into the United States and Canada. These insects cost many thousands of dollars each year, because there are no wild animals in North America that will eat them.

MAN TRIES TO CONQUER HARMFUL INSECTS

When men first tried to stop insects from eating their crops, they tried to kill them all. But it was discovered that this

Ladybirds eating cottony-cushion scale





Galloway

Fighting the boll weevil with airplanes

was not the thing to do, because animals will eat other kinds of food when their food becomes scarce.

The Australian ladybird beetle is a useful animal because it eats the cottony-cushion scale. Shield bugs eat the pupae of the ladybird beetles. If the shield bugs were destroyed because they feed upon the young of the Australian ladybird beetles, the ladybird beetles might multiply so rapidly that there would not be enough scale insects to feed them all. If this should happen, the ladybird beetles would look for other kinds of insects to eat. These insects might be useful. Not even scientists know whether the ladybird beetles, if there were too many of them, would be useful or harmful.

Certain government organizations are working with landowners, trying to help them to control harmful insects. They work with the farmers, helping them to check the many different kinds of animals that feed upon their crops. They have given the farmers thousands of tons of poisoned bran

to scatter over lands where grasshoppers are feeding. They help the farmers to organize into groups so that they can build trenches and pits to stop the chinch bugs from crawling from one field into another. Government organizations study the habits of the harmful insects and tell the farmers the things they should know about them.

By means of radio broadcasts and telephone relays, government weather bureaus let the farmers know about changes in weather. Weather forecasts during the season when fruit trees need spraying are very valuable to the farmers. If it should rain the same day that the trees were sprayed, the spray would be washed off before the young insects ate the poisoned leaves. But if it is not going to rain, even though it looks as if it were going to, the farmer should be told. Insects can do a great deal of damage in a day.

MAN UPSETS THE BALANCE IN STREAMS AND LAKES

Fishing has always been an important industry. Today there are about one hundred and thirty thousand men in the United States that depend upon fishing for a living. These fishermen catch about two and one half billion pounds of fish every year. If each fish were one foot long, and if all these fish were fastened in one long line, the line would be long enough to reach twice around the earth at the equator.

Fish hold third place in the list of animals sold for food. There are enough fish sold each year for every person living in the United States to have a little more than nineteen pounds apiece. Over one hundred million dollars' worth of these animals are sold yearly. Fish is the cheapest protein food that we can buy. It is also rich in fats and oils and many

of the necessary minerals and vitamins. Salmon, sardines, and shellfish contain large amounts of calcium. The livers of fish contain iron and iodine. The fats and oils in fish contain vitamin A, and the oils in some fishes supply us with vitamin D. Oysters, clams, and lobsters are of great importance because they contain vitamin C.

In recent years in many parts of the world adult fish have been taken from the water faster than the young have been able to take their place. This explains why fishermen have difficulty sometimes in catching anything except small fish.

When the people living in California noticed that the salmon-fishing was not so good as it had been a few years before, they hired some men to discover the reason. These men found that catching too many fish was only one of the causes. They learned that more than 80 per cent of the spawning, or egg-laying, grounds of these fish had been cut off by the building of irrigation and power dams.

In 1928 there were only about five hundred miles of streams in which the fish might spawn. Before the dams were built, there were nearly six thousand miles of spawning beds. The older fish are able to get by the dams, but many of the younger fish are not able to get by them. Large numbers of young salmon that pass by the dams never reach the ocean. They follow the downstream current toward the ocean and are swept into flooded lands, where they die from heat or as a result of the drying up of the water.

Many people had thought that catching too many fish was the only reason for the increasing scarcity. Since 1865 the amount of fish sold has more than doubled. Better fishing equipment has made it possible for fishermen to catch many more fish on a single trip than they were able to catch many years ago. Fifty years ago fishermen were using rowboats

Galloway

Thousands of salmon are caught by fishermen with this kind of fishing equipme

and sailboats that could not cover great distances. At the present time many fishermen use motorboats. There have also been improvements in nets and devices for landing or pulling in the fish after they are caught.

But fishermen cannot be blamed entirely for the smaller number of fish in our streams. A great many changes have taken place in our lakes and streams since 1865. Dams have been built. There have been many floods caused largely by the cutting of forests on hillsides along lakes and streams. These forests held back thousands of gallons of water. River beds have been deepened, causing a change in the type of animal life that can live in the deeper water.

Canning factories have appeared in different parts of the world. Better canning methods and refrigerator cars have made it possible to ship greater distances. This has encouraged fishermen to catch all the fish they could.

Industries, such as factories, mills, oil refineries, and tanneries, and the larger number of people living in cities are probably as responsible as fishermen for the disappearance of fish from many of our lakes and streams.

Industries and the greater number of cities in North America are making it necessary for us to find better ways to get rid of wastes. What are we going to do with the wastes from mills, factories, mines, and oil refineries? What is the garageman to do with dirty oil? What are people going to do with household wastes? The oil, wastes, and filth that are dumped into rivers sometimes poison the fish and destroy other kinds of water life as well.

Because both cities and industries grew so rapidly, we were not prepared to take care of their waste materials. So we did the easiest thing. We emptied the wastes into streams and lakes. And we did very little thinking about how such wastes might upset the balance of life in these bodies of water.

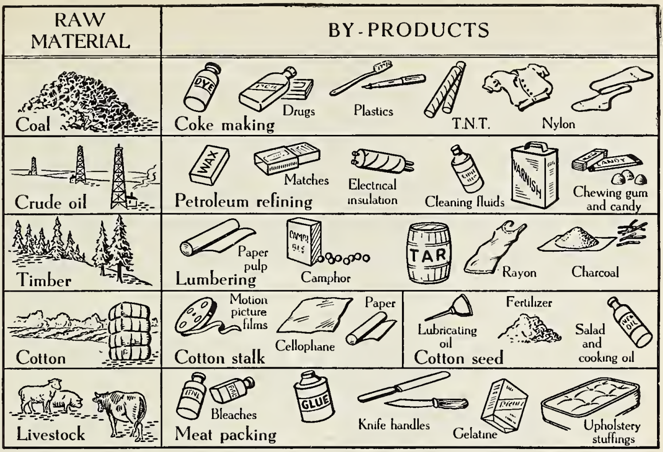
Since early times streams have been used for dumping grounds. Even early man threw the things that he did not

want into a near-by stream. It probably seemed a very easy and good way to get rid of them. When only a few people were throwing their wastes in the water, it did not matter. But when a large number of people use streams and lakes for their dumping grounds, it is quite a different matter. And when paper mills, cloth mills, tanneries, garages, and gas plants also dump their wastes in the water, it is much worse. Oil and gases added to the water kill thousands of fish and water birds. The nesting places of birds are also destroyed by them.

When oil collects on the top of water, it prevents the air from being added to the water; so even when small fish swim near the surface, they cannot get the air they need. Insects that come to the top of the water for air, also die because their supply of air is shut off. When ducks land on water covered with oil, they may never rise again. The oil soaks through their feathers and makes them too heavy to fly. The dumping of wastes into streams is called stream pollution. Stream pollution not only kills thousands of the animals that live in or on the water, but it spoils the stream for drinking water and for bathing.

But there is much less stream pollution today than there was a few years ago. People who are interested in saving water life, in using their lakes and streams for water supplies or for bathing, have done a great deal toward helping to clean up our streams and making them fit for animal life or for their own use.

However, there is still much to be done. In the Appalachian Mountains mineowners have been using the streams to carry off their waste materials. It costs the railroads running east from Pittsburgh millions of dollars a year for repairing the damage to the boilers of locomotives caused principally



Many valuable products can be made from waste materials

by water that was taken from streams into which waste materials were dumped.

Wastes emptied into streams may carry typhoid-fever germs. Oysters, milk, uncooked vegetables, and ice cream frequently carry the germs. Can you see why?

Stream pollution is not only a great waste of animal life but of mineral resources as well. The nitrogen in waste materials is a very important mineral for food-making in plants.

Through the sewers of cities pass waste materials, called sewage, which would be most valuable in fertilizing the land.

The rivers carry these valuable materials down to the ocean, where they cannot be used. Many cities are building sewage plants, which take the sewage and treat it so that fertilizers and other useful things can be made out of it. In this way the rivers are kept clean. At the same time tar, dyes,

drugs, grease, soap, turpentine, and many other things are made from the waste products, or sewage.

With your help stream pollution may become a thing of the past. You may have a very important part in the passing of laws that require the building of passes for young fish to get by dams in our streams. When these things are done we may have the thrill once more of seeing clear streams with abundant fish, and ducks landing in large flocks on our lakes and streams.

MAN CHANGES RICH FARMING LANDS INTO DESERTS

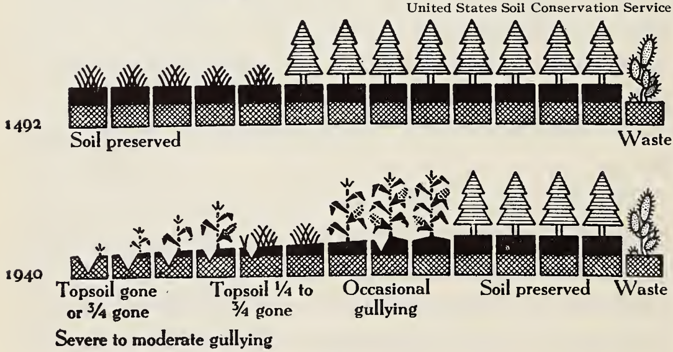
Many millions of years ago, when the wind and water were helping to form the first soil, they were also already at work blowing and carrying the soil away. Wind and water are the most important forces that erode, or carry away, soil.

It takes a long time for the wind and water to erode soil; but it takes even a longer time for soil to form. Rocks must lie open to wind, water, or sun for many ages to form good

---

The amount of erosion in the United States, 1492 and 1940

United States Soil Conservation Service



soil. Good soil, such as the farmers like, is not made in a few years. It usually takes from six thousand to ten thousand years for one foot of soil to form.

In order to raise food crops we must see that plants have the minerals which they need. Good soil contains nitrates, phosphates, potash, iron, and other minerals that plants use in making food. Billions of tons of these minerals are taken from the land each year when the crops are harvested. Many of these crops go to the cities, and only a few of the waste products are returned to the land. Most of the wastes fertilize the beds of streams or oceans, where fertilizer is not needed. Very few crops are ever plowed under to feed the soil. Even fewer animals are allowed to die in the fields and return the calcium, iron, nitrogen, and phosphorus which they took away from the soil when they ate the grasses and grains. The carrying away of millions of tons of food to the city is something that cannot be helped. But we can help to prevent much of the soil erosion that is taking place today.

The soil that washes out of the United States each year could fill a chain of freight cars long enough to reach around the earth thirty-seven times at the equator. During a single dust storm, enough rich soil was swept across the northeastern part of North America to fill a chain of freight cars long enough to reach around the earth ten times. Fifteen million acres of land in North America has been destroyed by erosion since the coming of white men. Every year twice as much soil is washed away as was removed in building the Panama Canal.

Some of the richest farms in the world lie in the central part of North America. During the last fifty years these farms, as well as many others, have been changing into poor farm lands. Men are largely responsible for these changes,

United States Soil Conservation Service

Hundreds of rich farm lands have been changed into poor farm lands because there were not enough plants to hold the soil and wa

because they removed the plants that helped to keep the soil fertile.

A great many forests have been destroyed during the last fifty years. When land was cleared for farming, thousands of trees were cut and burned. Many more thousands of trees have been used for fuel, for telegraph and telephone poles, and in paper-making. If all the paper made in the United

States and Canada during a period of four years were cut into strips as wide as a newspaper and if all the strips could be laid side by side, the paper would cover the distance from the earth to the sun and back. Many more trees have also been destroyed by fires that have started as a result of men's carelessness.

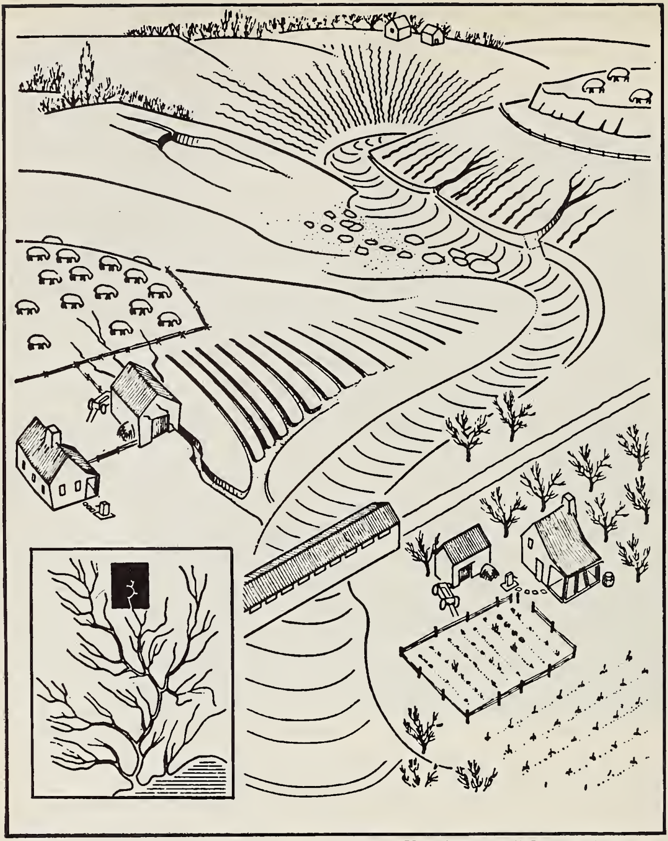
The roots of trees and smaller plants help to prevent the soil from being eroded or carried away. The roots of plants also help to keep the soil moist, because they loosen the soil by pushing through it in all directions. When soil is loose, there are more spaces in it that can hold water.

Perhaps you have noticed that rain water stands in puddles along the edges of sidewalks where no plants are growing. This soil has been packed so hard that there is not room enough for the rain water to seep into it. When the soil is tightly packed, water collects in puddles on top of the soil. The water in these puddles either evaporates or else it runs off carrying the good topsoil with it.

Some of our food plants hold the soil better than others. Soil is not blown or washed away so rapidly in fields where grasses and grains grow.

Grasses, a cloverlike plant called alfalfa, clover, and such grains as wheat, barley, buckwheat, and oats grow very close together. Since there are so many of these plants in a field, there are many roots to push the grains of soil apart. The stems of these plants grow so close together that the wind has very little chance to pick up dry pieces of soil and carry them away.

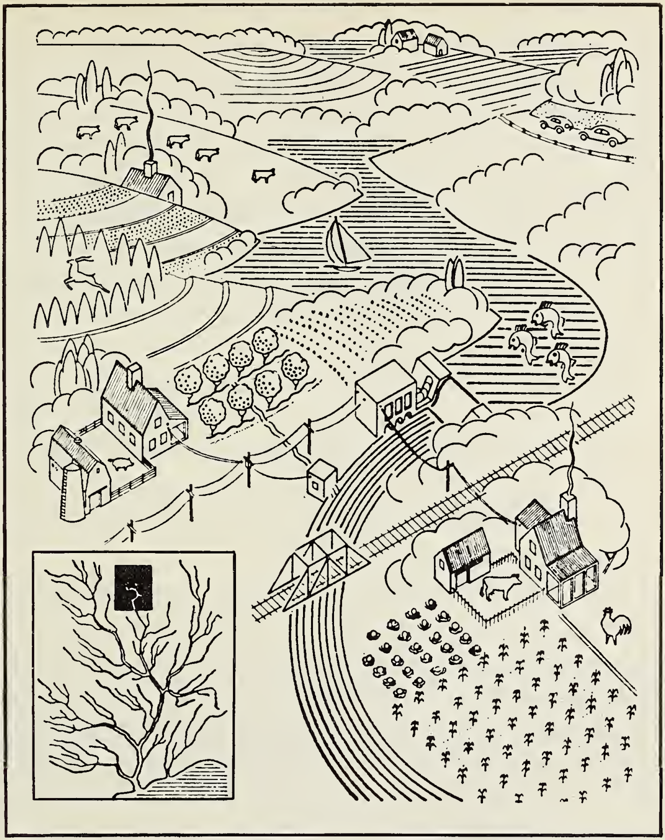
Soil is being eroded much more rapidly where cultivated plants grow. Beans, peas, corn, potatoes, cotton, and tobacco are a few of the plants that are called cultivated plants. These crops are sown in rows that are far enough apart so



United States Soil Conservation Service

Spring floods, polluted streams, and summer dust storms are caused by this type of farming

that they can be cultivated. Cultivated plants do not hold the soil so well as grains and grasses. They do not have enough roots to keep the pieces of soil apart so that there is room for water to seep between them. There are more spaces



United States Soil Conservation Service

A way to restore balance to farm lands in river valleys

between the stems of the plants, where wind and water can pick up soil and carry it away.

Pasturing too many animals in a field has also helped to change rich grassy lands into deserts. You have probably seen a few cattle or sheep wandering over the fields as they grazed.

You could hardly find the places where they ate the grass. But if ten or twenty more animals fed on the green plants in this pasture, you would see a big difference. When too many sheep or cattle graze in a pasture, they eat the grass much closer to the ground. They eat the grass so close to the ground that they nip off the tiny buds that would grow into new leaves. Grass that is cut very close to the ground has not enough of the green leaves left to make food for itself. The grass in these pasture lands cannot live without food. So many of the plants wither, loose their hold on the soil, and blow away.

Since there are not enough plants to keep the soil loose, it becomes dry. Wind and water will change a pasture into a desert very rapidly when this happens. Many pasture lands have been changed into waste lands in this way. Much of the dark soil that our ancestors plowed a few centuries ago now lies at the bottom of the oceans.

The loss of this soil makes it difficult to grow crops during a dry season. This dark soil, called humus, is composed of decayed plants. Humus does not pack so closely as the other materials found in soils. Water can seep into it and be held longer than in soil in which the humus is gone.

Is it any wonder that farmers are working together to prevent erosion? With the aid of their governments they are making a great deal of progress. In the next few pages you will read about some of the things that are being done to conserve the soil.

MAN IS LEARNING TO CONSERVE HIS SOIL

Many acres of land that used to be cultivated are being planted to grass. Grass is a very good weapon to use against soil erosion. Until recently even the best-cared-for

farms in America had as much as 10 per cent of their land without proper plant covering. Good grasslands make excellent pastures and lose very little soil and water. Grass-covered waterways and terraces, or furrows of grassland, in these meadows lead away the water that does not soak into the soil.

Steep slopes and gullies, or tiny valleys made by the wearing away of the soil, are being planted with trees and small plants. A dense forest growth breaks the fall of a heavy rain; and the water, after it strikes the ground, is slowed down by the many small plants, roots, and leaves on the forest floor. Trees and small wood plants are among our best protections against erosion.

But in order that many millions of people may be fed, we

Strip farming

United States Soil Conservation Service

Farm lands that a

United States Soil Conservation Service

ing used wisely

United States Soil Conservation Service

Grass-covered waterways are being built to carry water to a near-by stream or lak

must use our land for more purposes than growing trees and raising cattle. We must have food crops. Farmers are discovering that soil can be conserved on lands where food crops are grown.

Since soil erosion takes place very rapidly in large fields planted to cultivated crops, farmers have found it necessary to do strip farming. In strip farming, a field is divided into several parts called strips. Grass seed or grain is planted on each side of a strip of corn, beans, or other cultivated crop. This kind of farming helps to keep more of the soil in the field than there would be if only cultivated crops were grown. Water carrying soil from the cultivated crops is stopped by

the strips of grass or grain and most of the soil is strained from the water before it runs off.

Instead of planting fields of cultivated crops in straight rows that run up and down the field, the crops are planted across the slope or around the hill. When the plants are cultivated, the machine throws up little furrows that help to hold the water. In this way more water can soak into the ground. The up-and-down rows that were used in the past made furrows that acted like troughs to carry the water away. It flowed down the slopes, quickly carrying soil with it. Today you can drive for miles and miles in the Carolinas, Georgia, and Alabama without seeing a straight row of cotton or corn.

A field of corn in Iowa that had up-and-down rows lost 10 per cent of all the rain that fell and forty tons of soil per acre. Another cornfield planted with rows going around the hills and across the slopes lost less than one tenth of 1 per cent of the rain and no soil.

On steeper slopes, terraces are being built. Terraces are furrows of land built across the slope to prevent the rain water from running down the slope. Farmers either plow these terraces or sow them with grain or grasses. On the edges of the slopes, grains or grasses are planted to hold the terrace in place. Grass-covered waterways are built at the ends of the terrace to carry the water down the hill to the near-by stream or pond. In Nebraska a level terrace, half a mile long, held 118,500 gallons of water after one rainfall.

Eight hundred million acres of land in the United States has been cut into gullies or hollows by rain water rushing down the slopes and into near-by streams. Gully erosion can be stopped by planting these natural waterways to grasses or by making them into ponds to hold water. These ponds

can be used for building up surface and underground supplies of water, for watering stock, for swimming holes, or even for power. A farmer in North Dakota built a small dam for holding back enough water for his stock. During a very dry season the water from this little pond irrigated forty-two acres of land and supplied the water for fifty cattle. Such ponds draw wild birds and other animals.

Grazing lands can be protected by preventing too many animals from feeding upon them. Water for the cattle is being provided in many places by damming small streams. These ponds also help to conserve the water that would otherwise run off. More watering places help to store underground water and keep the soil around ponds moist. Moist soil will in turn grow more grass.

Many of the materials that are being taken away from the soil can be returned to the soil by growing different kinds of plants. This is called crop rotation. The soil materials taken out of a cornfield can be partly returned by planting it to clover, alfalfa, or small grains. These grasses can be used by cattle or sheep during the summer, and in the fall the field can be plowed under. In the spring this field could again be planted to corn.

How much longer will our country continue to throw away its resources?

Ding from *Better Homes and Gardens* Magazine

Many things are being done to prevent soil and water erosion. Farmers are finding that they cannot work alone on this important task, but that

they need to work with many people. They are discovering that they can conserve the soil and cultivate it at the same time. Conservation to the farmer means control and wise use.

Conservation of soil is just as important to all of us as it is to the farmer. Control and wise use of soil will mean cheaper farm products and more land that can be used for recreation, woodlands, and public game lands.

THINGS TO THINK ABOUT

1. Scientists say that there are at least 400,000 different kinds of insects. Every year men learn that more and more kinds of insects are valuable. Men are also learning that a few kinds of insects are becoming more difficult to control.

2. We could save about one cent on every loaf of bread we buy if the farmers could control the insects that destroy a part of their wheat crops each year.

3. Why would most foods be cheaper if harmful plants and animals were kept in check?

4. What helps to mix sand with plant and animal material to form soil?

5. The average depth of soil covering some parts of the earth may be only a few inches, and in other places it may be several feet. It has taken millions of years for small plants called fungi, wind, and water to make the soil covering on the earth. Why can running water carry away more soil than water that stands in puddles or ponds?

6. What may happen to all the soil that is deposited in the oceans?

7. What carries soil away? What things can men do to slow down soil erosion?

8. Young fish eat so many mosquito larvae that ditches have been dug in swamplands and minnows have been placed in the water that collects in the ditches. This method of getting rid of mosquitoes is cheaper and better than oiling water in swamps.

9. Placing oil on ponds or swamplands to kill mosquito larvae is very harmful to waterfowl that nest in these places.

10. In one year 250,000 miles of Hollywood scrap film was made into patent-leather shoes and pocketbooks. In the United States so much leather is used that nearly all the Mississippi Valley would be needed for grazing cattle for producing the required amount of real leather. The use of film in making artificial leather frees many acres of land for other purposes.

11. A few years ago Southern farmers had to pay to get rid of the old pine stumps in their fields. Today men pay the farmers for these stumps and remove them free of charge. Licorice, camphor, and insect poisons are being made from these stumps.

12. In the future we may not need to cut forests for their timber. Scientists have learned how to make man-made boards that will not split, warp, or rot. These boards can be made into any size or shape. They are strong enough to support the weight of an elephant.

THINGS TO DO

1. Humus is a very rich soil that is formed by decayed plant and animal material. Ask a farmer or florist how long it takes dead plant and animal material to form into humus.

It takes a long time to form humus. Make some humus by placing leaves, twigs, bits of bark, and any small dead animals, such as the fish that die in the aquarium, in a wooden box. Keep the decaying plants and animals as moist as they would be if they were out of doors. It would be a good idea to dampen these things once a day, because much of the water will evaporate. Toward the end of the school year plant seeds in this box.

Fill another box with humus from the woods or from a greenhouse. Plant seeds in this second box. Watch the seeds in these two boxes for several weeks. Which seeds grow better, the ones in the humus you are making or the seeds that grow in the humus from the woods? If possible, save the humus you are making for another year and try the same experiment again. It takes many years for fungi to break down plant and animal material into soil.

2. Experiment to find which is the stronger agent of erosion, clear water or water that carries dissolved minerals and coarse sediments. Find two cans that have tight covers. Place a piece of glass in each of them. Pour clear water into one can. Mix sand, gravel, and mud in water and pour this into the second can. Put

the covers on the cans and shake them. Examine the pieces of glass. Which piece has the more scratches? Coarse materials which scrape, grind, or wear down other things are called abrasives. Which can of water in this experiment contained abrasives? What kinds of abrasives does your mother use to get carbon off the bottom of her cooking dishes?

3. Experiment to prove that plowing deep furrows in soil slows down erosion. Get two boxes of soil and keep them until the soil becomes dry. Moisten wrapping paper and fasten it around the edges of the boxes. Use an electric fan or a piece of cardboard for making wind. Make a deep furrow in the soil in one of the boxes. Turn this box so that both ends of the furrow point away from the fan or from the side on which you are going to fan the box of soil with the cardboard. Let the air move rapidly over the boxes for a few moments. Examine the moistened paper around each of the boxes. Which has more sediment on it?

Loose soil lets the water run through it better than soil that is packed. Make holes in the bottom of two cans. Fill the two cans with soil from your schoolyard. Run your fingers through the soil in one can, and break up any of the hard lumps. Take a small hammer or some other hard object and pack the soil in the second can. Place saucers or pans under the two cans. Pour equal amounts of water in each can. Watch to see through which can the water runs faster. What things out of doors help to keep the soil loose, so that rain water can run through it?

4. Find a place in your schoolyard where the ground is bare and one where the ground is well covered with plants. Visit these two places on a windy day. Take two pieces of moist or sticky paper with you. Keep the pieces of paper in covered jars until you are ready to do your experiment. Remove one piece of paper from the covered jar when you reach the center of a plot where the ground is bare. Hold the paper close to the ground for a few seconds. Place this paper back in the jar and stand in the center of the plot where the ground is covered with plants. Remove the second piece of paper from the jar and hold it near the ground. Place the piece of paper in the covered jar. When you return to school, examine the two pieces of paper under a magnifying glass. Which piece has the more dust? What does this experiment prove?

IX

Man Learns to Use the Things That Make Up the Earth

MAN LEARNS ABOUT THE THINGS THAT MAKE UP THE EARTH

MAN LEARNS TO MAKE HUNDREDS OF NEW MATERIALS

MAN MAKES HIS WORK EASIER

WHEN we compare the thousands of years that people have lived on the earth with our own age, we think that people have been on the earth for a very long time. But when we consider how very old the earth is, we realize that it has been only a very short time. However, a great many things have been learned during this very short time.

The first human beings probably spent very little time considering the things that make up the earth. They were busy hunting for food and seeking shelter from storms, darkness, and wild animals.

Many years passed before men learned to raise animals and grow grains. They now had more free time in which to discover the materials that make up the earth and to learn how to use them.

Many of the discoveries made in ancient times must have been made by accident. But even in the past there were men who were great thinkers. More than two thousand years ago great thinkers tried to explain why the earth was made of so many useful metals. They wanted to find out what happened to metals when they were heated. At last human beings were wondering about the things that made up their earth.

There was so much to discover, it is no wonder that so many mistakes were made. Even today there are a great many things about the substances that make up the earth which we need to learn. Today we are just beginning to find the answers to the questions that men have asked for more than two thousand years.

In this story you will read about discoveries that have been made about the materials that make up the earth.

Man Learns about the Things That Make Up the Earth

WHAT ANCIENT MEN THOUGHT ABOUT THE MATERIALS THAT MAKE UP THE EARTH

For centuries men have wanted to make new things from the materials they found in the earth.

The ancient Greeks were probably among the first who tried to make new things. They were searching for a way to make gold. They thought that the gold they found in the earth had once been silver, mercury, or some other common metal. These people believed that if the sun's heat shone on the common minerals long enough, these minerals would change into precious metals.

People who tried to change substances which they found in the earth into other substances were called alchemists. Since the alchemists believed that the sun's heat changed minerals into other minerals, they thought they could make the minerals change faster by heating them.

It is not surprising that the Greeks thought such things. They knew so very little about the earth. It was their way of explaining the things that were taking place around them. The alchemists believed that water changed into earth because they thought they had seen it happening before their own eyes. They had noticed when they boiled water that the amount of water in the pan grew less and less until finally it was gone. When they examined the bottom of the pan in which they had boiled the water, they saw fine pieces of dust. These men did not know that water usually has some solid materials in it. They thought that they had changed water into solid earth.

© Hercules Powder Company. From a painting by N. C. Wyeth

The alchemists were among the first people to try to make new substances

A scientist using a microscope

The alchemists and their followers were so earnest in their beliefs that they worked over their red-hot furnaces day and night. They heated first this substance and then that until at last their money was gone and their health was broken. The alchemists failed in their search for a recipe that could change cheaper metals into gold; but their work was not all useless. They discovered by accident many ideas that were useful to the scientists that followed them.

WHAT MAKES UP THE EARTH?

Since the time of the ancient Greeks we have learned that the earth is made up of ninety-two elements and that some of these elements are found in air, water, earth, and fire.

An element is a substance that cannot be broken down into two or more different substances. Some of the common substances that you know are elements. The metals copper, tin, zinc, iron, mercury, gold, silver, lead, and aluminum are elements. Sulfur, carbon, oxygen, and phosphorus are also elements.

Most common things are made up of only a few of the ninety-two elements found in the earth. Think of it! Everything which is or was alive—all the different kinds of food, all the different kinds of plants and animals—are composed of two or more of twelve common elements. These twelve common elements are oxygen, carbon, hydrogen, nitrogen, phosphorus, sulfur, calcium, potassium, sodium, iron, chlorine, and magnesium. Many living things are made up almost entirely of the first four of these elements. The other eight elements are found in very small amounts.

Most of the twelve elements that make up living things also make up water, air, and the solid part of the earth. The

most common elements in the earth are oxygen, silicon, aluminum, and iron. These four elements make up about 87 per cent of the earth's crust.

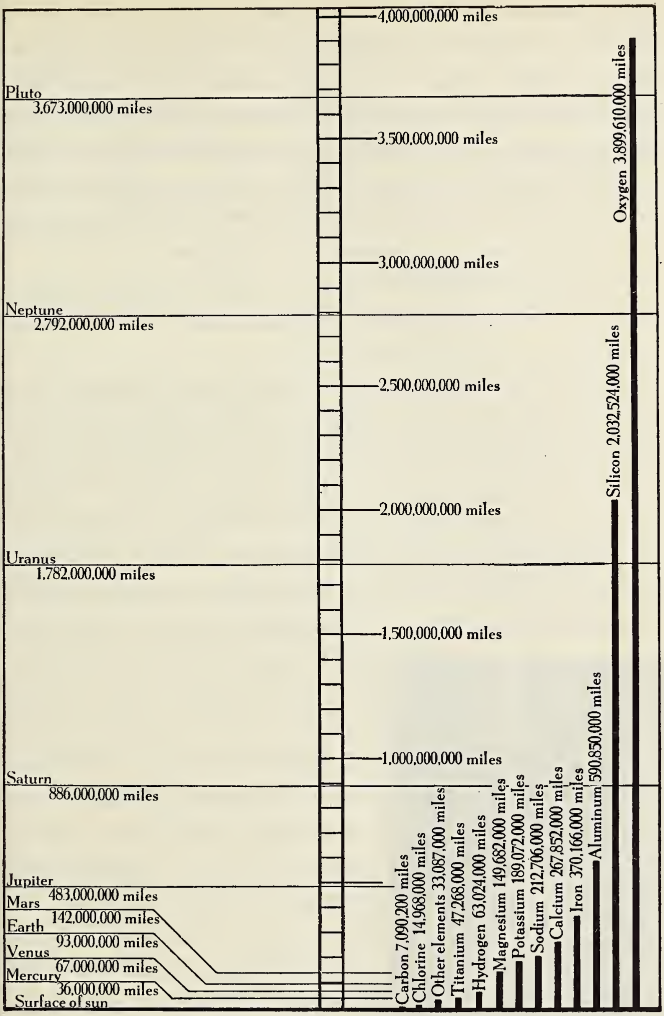
Perhaps you would like to know something about these four elements, oxygen, hydrogen, carbon, and nitrogen, that are found in living things.

There is more oxygen in the world than any other element. It is found in all parts of the world. It is in the food we eat, the blood that flows through our veins, the water we drink, the air we breathe, and in the rocks of the earth.

Oxygen is a gas that we cannot see or smell; but living things must have it. Living things need oxygen to change their food into a form in which it can be used. Fires cannot burn without oxygen. Steam engines, automobiles, airplanes, and other engines that use coal or gasoline must have oxygen. Oxygen helps to change fuel into gases. The gases furnish the force that makes the wheels go around. Oxygen is important to us in many ways.

Hydrogen is another element that is important to man. It is found in all kinds of plant and animal materials. Water is made up of hydrogen and oxygen. Hydrogen is like oxygen in one way. It is most useful in the form of a gas. Hydrogen is the lightest gas known. It was once used in balloons and dirigibles. Today we are using helium gas in dirigibles, because it does not burn so easily as hydrogen. Helium is an element that is found in the crust of the earth. However, hydrogen is still a very useful element. Hydrogen combined with other elements forms the acids that doctors, chemists, or people who work with chemicals, electricians, and housewives use for many different things.

Many useful elements are found in the form of solids. The solid element carbon is very important. Carbon is found in



If the elements in the surface of the earth were stacked in piles, this would be the result

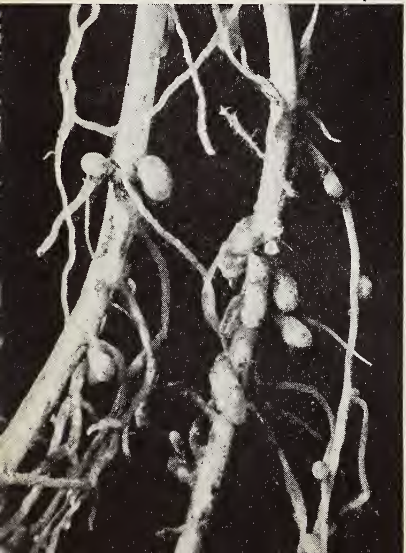
plants and animals. It is in our bodies, in trees, in the fuel we burn, and in the things we eat. Diamonds and the graphite or so-called "lead" in our lead pencils are both carbon. The carbon which formed the diamond had been heated and pressed harder in the earth than the graphite used for lead pencils. Carbon may be as black as coal or as clear as the crystal we call a diamond. Black carbon is used for making automobile tires, inks, paints, and varnishes.

Over three fourths of the ocean of air in which we live consists, or is made up, of the element nitrogen. Living things must have nitrogen in order to live.

Most living things, however, cannot use nitrogen in the form in which it is found in the air. They depend upon a few plants to take the nitrogen from the air and add it to the soil.

These potato-shaped balls are the homes of bacteria that change nitrogen into compounds that green plants need

Spencer



For many years farmers planted certain kinds of plants, such as peas, beans, and clover, in their fields. They learned that these plants improved their soil; but they did not know why. When scientists studied these plants, they found tiny round things on their roots that looked like very small potatoes. They found that these small potato-shaped balls were the homes of bacteria. These bacteria can take nitrogen from the air in the soil and unite the nitrogen with oxygen and certain other elements in the soil, such as potassium. When this new material

dissolves in water, plants use it in food-making. When nitrogen is united with hydrogen it makes an excellent fertilizer.

Animals must get the nitrogen they need from certain kinds of plants or from other animals which have eaten these plants. Most plants get their nitrogen from fertilizers or from bacteria that take it from the air.

ELEMENTS UNITE WITH OTHER ELEMENTS TO MAKE COMPOUNDS

The ninety-two elements are something like the twenty-six letters in the alphabet. Think of the thousands of words in the dictionary! People have learned to form these thousands of words by putting the twenty-six letters of the alphabet together in different ways. Thousands of new materials have been made by uniting the ninety-two elements in different ways. A compound is made by uniting two or more elements. A compound is always made up of at least two elements. But sometimes compounds are made up of half a dozen or more elements. Everything is made up of one or more elements or one or more compounds and elements.

Water is a very common compound. Water consists of the two elements oxygen and hydrogen. Water has different amounts of these two gases in it. There is twice as much hydrogen in water as there is oxygen. Water is found in all living things and in most of the rocks of the earth.

Carbon dioxide is a compound. It contains three atoms, which are parts of matter that cannot be broken down. It is made up of one atom of carbon and two atoms of oxygen. This compound is found in the air, in the rocks of the earth, in some mineral springs, and in living things.

Carbon dioxide is made by plants and animals. This compound is formed by living things when their food is changed into a form in which they can use it. Animals are really the most important producers or manufacturers of carbon dioxide. Green plants, in making food, use most of the carbon dioxide which animals produce. Every time we breathe out, we add more carbon dioxide to the air. Carbon dioxide is also formed by the decaying of plants and animals.

Fuels, such as wood, coal, oil, and gasoline, are rich in carbon. When wood burns, the carbon in the wood unites with the oxygen in the air and forms carbon dioxide.

Rust is a compound made up of iron and oxygen. Although people talk a great deal about the element iron, not many of them have ever seen it. All the iron mined from the earth is really iron rust or some other iron compound.

Iron is one of the most difficult metals for men to keep in the form they want it. When iron is left in the moist air, it slowly unites with the oxygen in the air and crumbles into pieces. For this reason men often cover iron with nickel, copper, zinc, and tin. But in time even these elements wear off, and the iron begins to rust.

Iron is present in small amounts in most green plants and in most animals. Green plants and our blood have iron in them. The iron in our blood helps us to fight diseases. If there were not enough iron in our blood, disease germs would multiply too rapidly and conquer us. Iron is important to human beings as well as to other living things.

Next to iron, aluminum is probably one of our most important metals. Aluminum is usually found in compounds. Recently a way has been found to remove aluminum from its compounds. Because aluminum is so light in weight and so strong, more and more uses are being found for it.

Aluminum is a good conductor of electricity. Trolley wires and other kinds of electric wires or cables are often made of this metal.

Much of the aluminum made in America is used in the bodies of cars and in the frames and wings of airplanes.

Most of the things that we think are made entirely of aluminum are really made of an alloy. An alloy usually contains a large amount of a certain metal and smaller amounts of other metals. The fuselage, or body, of airplanes is usually made of duralumin. Duralumin is an alloy of aluminum. Duralumin is made by uniting aluminum with the elements copper, magnesium, and manganese.

Aluminum is becoming as valuable to us as iron and copper. Perhaps we are just entering the age of aluminum. Who can say what things will be made of this metal in the future?

Quartz is another very common compound. It is made up of the elements silicon and oxygen. Most of the grains of sand along the seashore are quartz. Quartz is a very hard compound. As the ocean waves pound sand and pebbles against the rocks along the shore, the rocks are slowly worn down. The softer minerals in the small pieces broken from the rocks are washed away. The quartz grains are left as fine white sand.

Quartz is useful in many ways. Quartz is mixed with other elements to make lenses, mirrors, eyeglasses, safety glass, and window glass. With the aid of lenses, scientists have learned about the things in the universe that are too small or too far away to be seen with the unaided eye.

As men have learned more and more about the materials that make up the earth, they have discovered that some elements and compounds are necessary for living things. They have also learned to make new things that are useful to them.

THINGS TO THINK ABOUT

1. How can there be so many different substances when there are less than a hundred different elements used in these substances?

2. Some of the elements which you may often hear discussed are chlorine, cobalt, copper, gold, iodine, lead, magnesium, mercury, nickel, phosphorus, platinum, potassium, radium, silver, sodium, tin, and zinc. What common elements do you use in your home? How do you use them?

3. What happens to all the pins, nails, and hairpins that are lost?

4. Why would it be impossible for men to live where iron will not rust? Many of the colors in rocks, minerals, and soil are due to the presence of iron. The red, brown, orange, and black colors in rocks are made by iron compounds. Some precious stones, such as the ruby and the garnet, are red because of the presence of iron.

THINGS TO DO

1. Wet the inside of an olive bottle by pouring water into the bottle and out again. Sprinkle some very small pieces of steel wool or very small tacks into the bottle. The water causes them to stick to the sides and bottom. Pour out any loose filings. Now turn the bottle upside down and fasten it over a pan of water, with its mouth a little way below the surface of the water. Allow it to stay that way for several days. Why does the water rise in the bottle? What happened to the iron? What does the iron now contain?

2. You can see that water is formed when hydrogen is burned. Light a candle and hold a cold bottle just above the flame. When the hydrogen that is in the candle unites with the oxygen of the air, they form water. This water collects on the bottle.

3. Scientists have worked out a kind of code to use when they write the names of elements and compounds. Each element has a symbol or letter which is used in place of writing the name of the element. O stands for an atom of oxygen, H stands for an atom of hydrogen, and Fe stands for an atom of iron. Look at this list of some of the common elements and their symbols. You need not learn them.

Name	*Symbol*	*Name*	*Symbol*
Oxygen	O	Sodium	Na
Carbon	C	Silicon	Si
Sulfur	S	Phosphorus	P
Nitrogen	N	Chlorine	Cl
Aluminum	Al	Calcium	Ca
Iron	Fe	Zinc	Zn
Copper	Cu	Silver	Ag

4. Examine some iron rust. How does it differ from iron and oxygen, of which it is composed? Why is it that tools made by man a few hundred years ago are seldom ever found today?

5. Examine water. How does it differ from hydrogen and oxygen, of which it is composed?

6. Examine the tarnish, or dark stains, on silverware. How does it differ from silver and sulfur, of which it is composed?

7. Notice wood that has been burned in a campfire. Can you find the black substance which is carbon? Heat a little sugar in an old pan and notice that it turns black. What is left?

8. Look at some white sand. This is made of two elements, silicon and oxygen.

Man Learns to Make Hundreds of New Materials

SCIENTISTS LEARN HOW TO MAKE MANY NEW PRODUCTS FROM COAL TAR

As men continued to experiment with the materials that make up the earth, they made a very important discovery. They found that they could make hundreds of new products from coal tar, which is a product formed during the manufacturing of coke.

Coke is made from soft coal by heating it in airtight ovens. As the soft coal is heated, coal gas and coal tar separate from it. The product left in the airtight ovens is called coke.

For many years the men who bent over the hot coke ovens considered coal tar a nuisance, because it plugged the gas pipes leading from the coke ovens. They did not know what to do with the coal tar, so they washed it out of the pipes and dumped it into the creeks and rivers. Fishermen com-

These are a few of the many products made from coal tar

Monsanto Chemical Company

plained that the coke-makers spoiled their streams. For this reason the coke-makers stopped emptying the coal tar into the streams and tried to give the coal tar away.

When chemists studied this problem, they found that coal tar is one of the most useful things in the world. Coal tar is made up of twelve materials. Out of these twelve materials chemists have made hundreds of new things. A very thick sticky substance called pitch that separates from the coal tar is used for roads and roofing. Out of the rest of this product, chemists make perfumes, medicines, supplies for kodaks, motion-picture films, and dyes.

Less than a hundred years ago coke-makers thought coal tar was worthless. Coke-makers just could not get rid of the coal tar. Scientists discovered that this product which used to be thrown away is very valuable.

MEN CHANGE THE COTTON PLANT INTO DIFFERENT KINDS OF CLOTH

For several thousand years people raised many different kinds of plants and animals for the materials they needed to make clothing. Cotton seeds were planted in order to get the cotton fibers or threads to make cotton cloth. Flax seeds were raised for the fibers needed to make linen. Many sheep and silkworms were raised to provide wool and silk. Thousands of men, women, and children in different parts of the world toiled long hours in the fields and factories so that they and other human beings might have the cloth they needed.

People do not have to work so hard today to make cloth as they did in the past. Less than a hundred years ago an Englishman who printed designs on cloth discovered that a cotton fiber could be made to look like silk. Since that time

Spencer

Fibers of silk, rayon, cotton, and wool look like this under a magnifying glass

it has been found that a cotton fiber can serve the purposes of silk, linen, and wool.

Cotton fibers are composed of a substance called cellulose. The word *cellulose* means "little cell." Cellulose forms the walls about the cells of plants.

Before the cellulose can be spun into thread, it has to be dissolved. The cotton fibers are first placed in a bath of nitric and sulfuric acids. From this acid bath they pass into a bath that contains ether and alcohol. The ether and alcohol dissolve the fibers into a yellow liquid. The yellow liquid is forced through tiny tubes into warm water or warm air which changes the liquid into threads. These threads look very much like silk threads. After the threads have been dyed, they are placed in weaving machines and made into cloth called artificial silk or rayon.

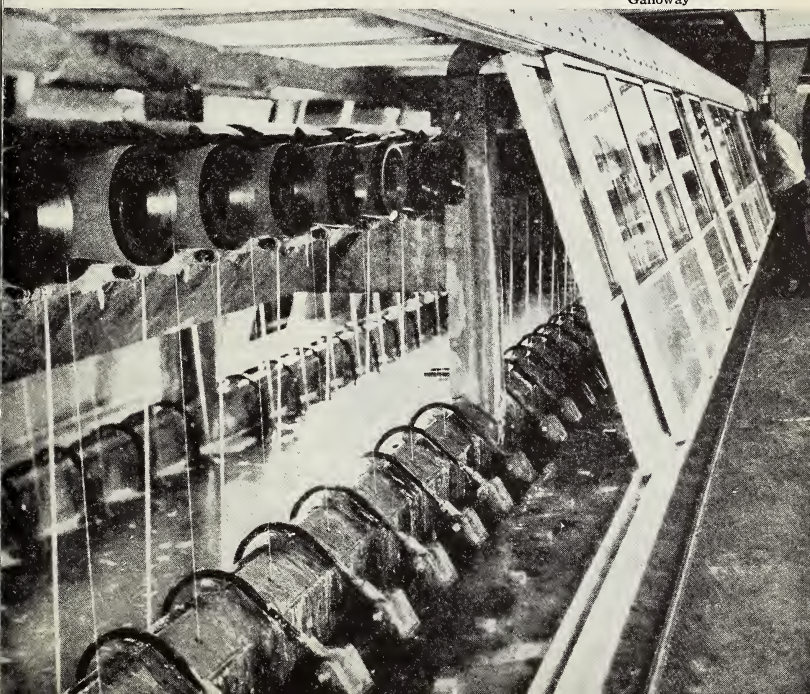
Not long after artificial silk was discovered, a machine was invented that could make nets and laces without weaving them. The cellulose liquid is poured over a revolving roller in the machine upon which the net or lace pattern has been carved. The cellulose liquid fills the design on the roller. A scraper removes the liquid that stands out above the engraved pattern. Then the liquid on the roller whirls

through an acid bath which hardens it. Most of the laces and nets worn today are made by this kind of machine. Someday even silk cloth may be made in this way rather than by weaving it.

A hundred years ago many more men were needed to plant and harvest cotton and flax and to manufacture cloth than are needed today. The discovery of cellulose cloth has helped to make it possible for fewer people to make the clothes we need. In the future cellulose may prove to be of even greater importance to us. Perhaps it will be used in place of lumber.

aking cloth from cellulose. Large revolving spools wind up the thread after it has been hardened

Galloway



MAN SEARCHES FOR A WAY TO MAKE MORE AND MORE RUBBER

The Indians living in Brazil have gathered the sap from the rubber trees for many centuries, and heated it over fires to make it hard enough to use. Indian children used rubber for bouncing balls. It was one of the few toys they had. The Indians used rubber for waterproofing many things. Many years passed before other people used rubber, because it got smelly and sticky in hot weather.

Charles Goodyear discovered how rubber could be made hard enough to use in all kinds of weather. He found that when the sticky caoutchouc, or soft smoked rubber, was heated with sulfur it changed into a very hard rubber. Caoutchouc is the Indian name for rubber. You pronounce it as though you were sneezing. At first this hard rubber was made into rubbers to keep the feet dry, and into clothing. Then other uses were found for it.

If you have ever ridden over dirt roads in a wagon, you know that it is not very comfortable riding. Every time the wagon goes over a rut, you get the full force of the bump. The first carriages were just as uncomfortable. Even the solid rubber tires were not much better. But after air-filled tires were made, travel over the roads was much more comfortable.

An ancient way of preparing rubber

An Irish doctor, John Boyd Dunlop, made the first air-filled rubber tires, for his son's tricycle. He wrapped air-

The Goodyear Tire and Rubber Company

modern way of preparing rubber. The sap is collected in pails and strained before shipping it to the factory

filled rubber tubes around the rims of the tricycle wheels. You can imagine how much better John Dunlop's son liked to ride his tricycle after that. The boy was not so likely to bite his tongue every time he pedaled over bumps. The air in the tires acted like a cushion. When the tricycle went over a hole in the road, the rim of the wheel struck against the air in the tire instead of the solid earth. A few years later factories were making many thousands of air-filled tires.

When automobiles were invented, more caoutchouc was needed to make tires than the native trees of Brazil could produce. Because of the great need for more and more rubber, men began planting rubber trees. Most of the rubber

today comes from these plantations. It takes a long time to grow rubber trees large enough so that they can be tapped. Rubber trees could not be grown fast enough to supply the rubber which was needed.

Since the ever-growing need for rubber cannot be fully supplied from rubber plantations, chemists are experimenting to find a way to make artificial rubber. Many more things will be made of rubber if chemists can find a cheap way to produce it.

Perhaps in the future rubber will be used for pavements, carpets, roofing, and painting. Even locomotives and subway trains may run quietly on rubber wheels and ties. One scientist has said that there may never be enough rubber. Perhaps some day we shall have all the rubber we can use!

THINGS TO THINK ABOUT

1. A London schoolboy, William Henry Perkin, discovered aniline dyes. He had spent many long hours trying to work an experiment. When he was washing his glassware, he noticed that the coal tar with which he had been working changed to a purplish color when he poured water into it.

2. There are many other uses for aniline dyes than for dyeing clothes. Aniline dyes are used to make certain foods a prettier color. The icing on your birthday cake would not be pink, frankfurters would not be reddish brown, and some butter would not be so yellow if it were not for aniline dyes.

3. The secret of making artificial silk was lost for more than forty years because people refused to pay any attention to a calico printer's discovery. He discovered that when cotton was soaked in a bath of lye and water the cotton shrank into a fine strong fiber.

4. Soft rubber, or caoutchouc, was first used in England as an eraser to rub out mistakes in writing. The English called it India rubber.

5. Many discoveries are made by accident. Mr. Goodyear had been working for more than ten years, trying to find a way to harden rubber. One day he spilled some caoutchouc and sulfur on the hot kitchen stove. He was amazed to see the sulfur change the soft rubber into a much harder substance.

6. What happens to the air in a tire when the tire strikes a hole in the road?

THINGS TO DO

1. Look for American silkworm cocoons hanging on the bushes along the roadside in the fall or early spring. Follow one of these insects from the egg stage or from the cocoon through to the adult moth. Caterpillars eat their weight in food every day. Many adult moths do not have any mouth parts; so they cannot eat. It is the caterpillars, or larvae, of moths and butterflies that do the damage. Think of the hours men work to raise enough caterpillars to spin the cloth needed for a single dress!

2. Read the story of how the secret of silk-making got out of China and spread through European countries.

3. Look at silk, cotton, and woolen cloth under a hand lens. Pull out a thread from each of these different kinds of cloth and examine them under the hand lens. See if you can tell the difference between rayon and real silk by examining it under a hand lens. Real silk is spun by insects. It is a nitrogen compound. Rayon is made from cotton. It is a carbon compound.

4. An air-filled rubber ball strikes an object with less force than a solid object because the air in the ball is compressed. Bounce an air-filled rubber ball. Cut a hole in the ball and try to bounce it.

Man Makes His Work Easier

MAN LEARNS TO INVENT MACHINES

Men who lived before the age of tools had to kill the animals they used for food with their own hands. These were very dangerous times. Human beings were usually in danger of being eaten. Just imagine how very exciting it must have been to go hunting without any weapons!

Cave men may have had favorite hiding places near water holes or other bodies of water where they waited for animals to come down to drink. They probably spent many long hours hiding in bushes or behind trees waiting to spring on the animals as they passed. Sometimes these ancient men proudly carried their game back to their families. At other times the animals may have carried off the cave men.

No one really knows how cave men happened to begin using sticks and stones for tools. But scientists believe that tools were used more than twenty thousand years ago. Perhaps some ancient man happened to pick up a stick and killed an animal that was attacking him. This may have given men the idea that they could use long clubs for hunting wild animals.

These clubs were levers. A lever is one kind of machine. Men found that they could strike animals with greater force when they used clubs, or levers.

Cave men may have discovered another way to use a club, or lever, to help them to do their work. Perhaps the entrance to a cave was too large. Maybe a cave man saw a stone lying near his cave entrance that was just the right size to make this opening smaller. Since the stone had been lying there for centuries, it was probably stuck fast in the earth.

Man early discovered the use of the lever

So the cave man had to tug and tug as he tried to loosen it. He may have called his family to help him. For a while it may have seemed to them as though no one could move the stone. Then when everyone was ready to give up, the cave man had an idea. He reached for his favorite hunting stick to scrape away the soil under the stone, and quite by accident his stick got caught under it. When he tried to jerk

his stick loose the stone moved, too. Cave men may thus have learned how to use levers for prying up objects that were too heavy to lift.

An automobile jack is one of the many different levers we are using today

Later it may have been discovered that large stones could be moved still more easily by resting a part of the club on a smaller stone or stick when they tried to lift the heavy stones.

Sticks were probably used for levers for many thousands of years before stone tools were made.

At last some cave man discovered that he could tie a stone to a stick. This made a much better weapon than the old hunting club. The stone on the end of the stick helped him to break things apart much more easily than he could do it with his hands. Tools that pry things open are wedges. A wedge is another kind of machine.

This new weapon may have been used like a hammer to kill other animals and to break stones into smaller pieces. The handle of the weapon was a lever and the spearhead or axhead was a wedge. This new tool that consisted of a lever and a wedge may have been the first compound machine. The word *compound* means "something that consists of more than one thing." A compound machine consists of two or more machines put together to make one machine.

At first these ancient levers and wedges that were combined into compound machines were very poorly made. But as they were used they were improved. Stones that were to be used for weapons were polished. Smooth stones go into the flesh of animals deeper than rough stones. Furrows, or grooves, were cut on the ends of stone wedges so that they could be tied more tightly to the handles of spears and axes.

These men who used stone tools lived more than twenty thousand years ago. The period during which they lived is called the Stone Age.

No one really knows when human beings first used rollers or wheels to help them to move heavy objects. We shall just have to imagine how it may have happened. Perhaps an ancient man picked up a log and started to carry it to his home to burn on his fire. The log seemed to grow heavier and heavier because the man was getting very tired. He may have dropped the log. When the log struck the ground, it probably rolled for a short distance. If the cave man saw this, he probably forgot how tired he was and shoved the log for a short distance, hoping it might roll once more. And again the log may have rolled away from him. He then decided that shoving the log was much easier than carrying it. If this happened, that ancient man's family must have been much surprised to see him rolling a piece of wood which they had always thought must be carried.

Only a very small part of a wheel touches the ground at one time

Later it is likely that the men of the Stone Age discovered that they could haul their loads on two wooden rollers. The first rollers were probably logs that were placed under the front and back end of an object that was to be moved. Much heavier loads could be hauled on these crude rollers or wheels. Wheels are another kind of machine. Rollers or wheels cut down the friction, or rubbing, between the load and the ground. It takes force to rub one object over another. When the friction, or rubbing, is reduced, less force is used in rubbing. When less force is used in rubbing, there is more force left to push or pull the object. Rollers reduce the amount of friction, because only a very small part of a roller or wheel touches the ground at any one time.

It is believed that very crude wagons that had four wheels were built during the latter part of the Stone Age. The wheels were probably short pieces of logs that had holes bored through the center of each piece. Logs that were smaller in diameter than the wheels may have been used for axles, or the supports on which the wheels rotated. It is probable that strips of animal hide or wooden pegs held the wheels on the axles. Scientists believe that wagons like the one described were made during the Stone Age.

It took many centuries for the men of the Stone Age to learn how to use levers, wedges, and wheels and axles. It must have taken them a much longer time to learn how to put these simple machines together into compound machines.

The Stone Age ended when men learned how to remove metals from their ores, and a new age began. This new period in the progress of man is called the Bronze Age, because human beings no longer made their tools from stone but from bronze.

The men of the Bronze Age were farmers as well as metal-workers. They were probably the first to discover that a sharpened stick shaped like a fork could be used as a plow. The forked part of the stick served as a wedge to pry open the soil. The handle was a lever that helped to push the wedge through the soil. It was very hard and slow work for these ancient people to plow their fields. An acre of land planted in crops must have been considered a large field in those days.

Forked sticks had been used for plows for many hundreds of years before someone thought that plowing would be much easier if there were a handle on the front end of the plow as well as a handle on the back end.

Two men were needed to operate this new plow. One man pulled the plow while the other pushed down on the handle. A two-man plow was a real improvement over the forked stick, because two men could work faster than one. With the aid of this improved plow the farmers of the Bronze Age could plant larger fields in food crops.

Hundreds of years passed before animals were used to haul heavy loads and work in the fields. Oxen took the place of the man who pulled the forked stick through the ground. Since oxen can pull heavier loads than men, more land could be plowed. As these improvements were made, larger and larger fields were planted into food crops.

After the crops were grown, they needed to be harvested. At first the grain and grasses were cut with a wide, straight knife that acted like a very sharp wedge. Later ancient men learned that if the blade were bent, it would work better.

During the Bronze Age grains and grasses were cut with bronze sickles. A picture on the walls of a building in ancient Thebes shows two men cutting grain with sickles. It also

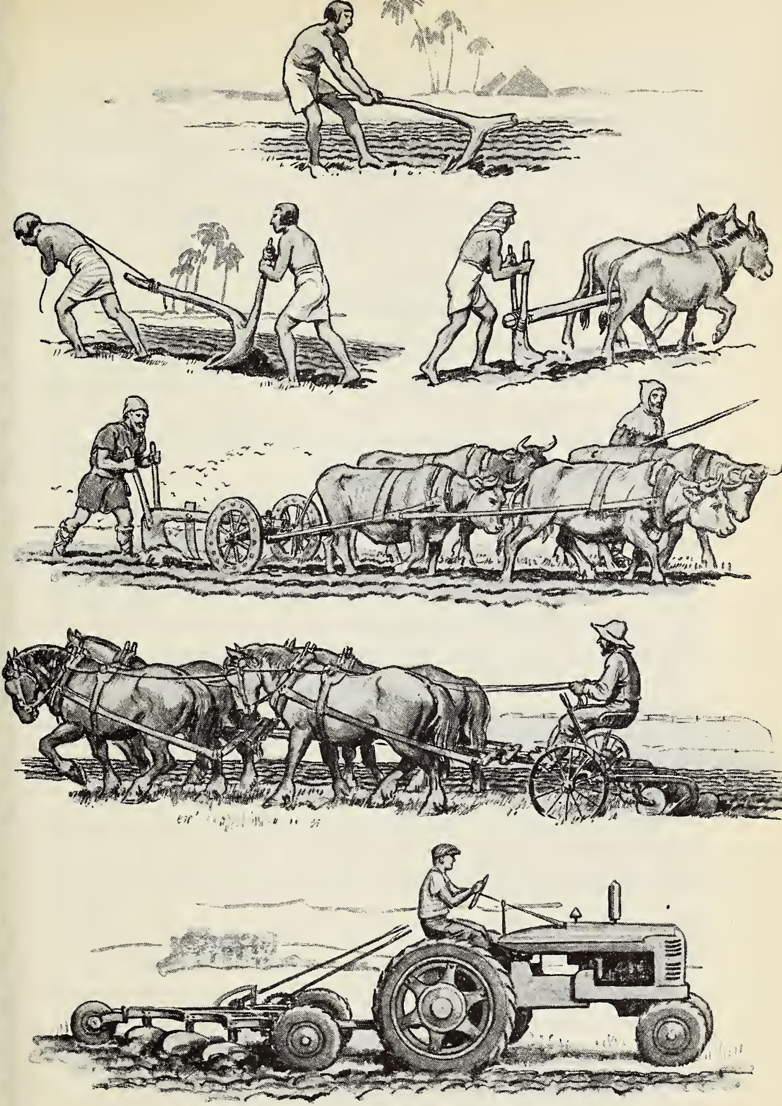
shows two other men carrying the grain to the place where it was to be threshed by oxen.

It was not until the Age of Iron, or the Machine Age, that plows and sickles were improved and new kinds of farm machinery were invented. In the Age of Iron, or the Machine Age, when the first steel blades for plows were invented, many people were afraid to use them. Some of the people thought that iron blades would poison the soil and the crops. Others thought that weeds would grow much faster if iron plows were used. But after a while they gave up those ideas. Today most plows are made of iron or steel.

The early colonists, or people who lived during colonial days, in America used a scythe that had prongs on it, or objects shaped like fingers. These fingers were placed near the blade, where they caught the grain as it was cut. The fingers dropped the grain in bunches. Men who followed behind the cutters tied the bunches together. This scythe was called a cradle and was used until later improvements were added.

In 1831 Cyrus H. McCormick made a machine called a reaper, which cut much more grain than could be cut with scythes or cradles. This reaper did the work of six men. Since 1831 harvesting machinery has been greatly improved.

Today, on many large farms, great compound machines called combines are used. These compound machines are called combines because they cut the grain, bunch it, and thresh it in one operation. After the grain has gone through these great combines, all the farmer has to do is to load the sacks of grain on trucks and store it away until he is ready to sell it. These new kinds of machinery have made it possible for men to care for fields many times larger than the ancient farmer could have dreamed of caring for.



Plows as well as other farm machinery have been greatly changed since the days when men first learned to farm

Less than two hundred years ago nearly everyone lived on a farm. Even then it was difficult for people to raise enough food to support their families and the few people who lived in cities. In this short time many machines have been invented for plowing, planting, cultivating, and harvesting grains. Farmers are now using milking machines, milk separators that separate the cream from the milk, and water pumps. Machines like these have made it possible for a very few men to raise enough food for their families, for the many thousands of people who have moved to cities, and for people living in foreign countries as well.

There has been great improvement in other kinds of machines besides farm machinery. By combining, or putting together, such simple machines as levers, wedges, and wheels and axles, men have learned to make huge machines for manufacturing clothing, preserving and canning food, and for lifting great loads and carrying them to all parts of the world.

The invention of machinery has made it possible for people to earn their living in many different ways. Some work on farms, others in factories, mills, stores, or offices.

Because machinery can do more work than human beings can, it has shortened the working day. Men used to work from sunrise to sunset in order to raise enough food to supply their families. Women used to spend long hours cooking, cleaning, canning food, spinning, weaving, and sewing.

With the aid of machinery we can produce all the clothes and food we need. Many are asking why there should be any poor persons since we can produce so much.

Machines have made it possible for us to have time to read, explore, experiment, and play.

As we continue to learn more and more about the things that make up the earth, we shall discover new ways to put simple machines together to help us to make living easier. This will give us still more time in which we can think and wonder about the universe of which we are a part.

THINGS TO THINK ABOUT

1. What countries in the world use very few compound machines?

2. With the invention of modern machines, civilization has advanced more in the last hundred years than in all the centuries before. Why does machinery help men to progress?

3. How do machines help you?

4. What things do you have that are not machine-made?

5. Why do not people have to work so many hours to earn a living today as they did even a very few years ago?

6. During the colonial days in the United States and Canada the parts of machines were handmade. When any part broke or wore out, the whole machine had to be sent to the man who made it. Sometimes it took several weeks and even months to get the machine repaired. People in those days often bought new machines rather than wait for the old ones to be repaired. Since then men have invented machines that turn out thousands of parts for each piece in a machine. These parts are called standard parts, because they will fit into any machine for which they are made. Why are the machines that make only standard parts so important to us?

7. Scientists think that axes, spears, and boring and cutting machines were the first compound machines used by human beings. Toward the end of the Stone Age men may also have learned to use rollers to help them to haul wood and the large animals they killed for food.

8. Men have invented compound machines that make it possible for a modern farmer to do about fifty times as much work as the farmer in the Bronze Age.

X

Man Discovers That His Mineral Resources Must Be Conserved

MAN WASTES VALUABLE MATERIALS

WE LIVE IN AN AGE OF IRON

MAN NEEDS METAL FOR HIS CIVILIZATION

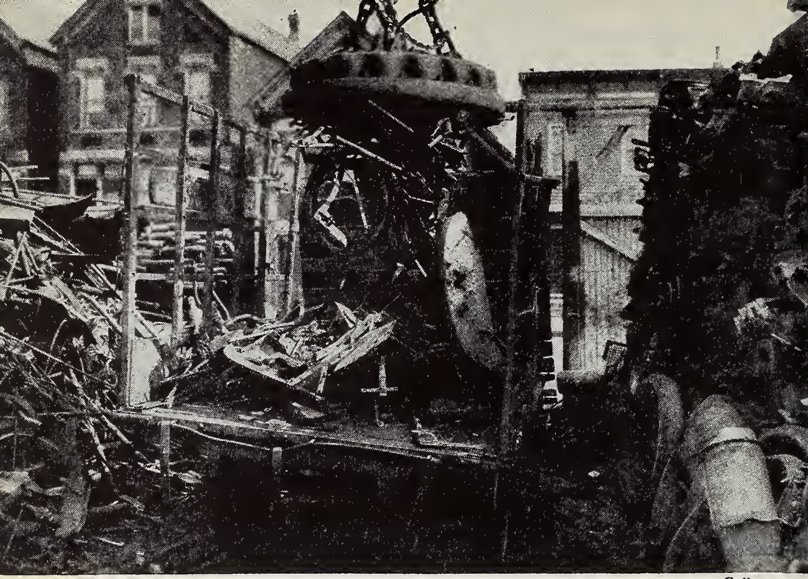
MAN NEEDS MINERAL RESOURCES THAT ARE NOT METALS

DID you ever think how many times every day you or some member of your family makes use of minerals? Think of the many things in your home which have come from minerals that were once stored away in the earth. If all these were taken from you for one day, think what a hard time you would have. You would have no stoves, clocks, pen points, nails, pins, or coins.

Miners are at work every day mining the minerals that we need. Some of these minerals that are mined are near the surface of the earth. Some are hundreds of feet beneath the surface of the earth. These deposits are called mineral resources. What would happen if all these mineral resources were used up and there were no new supplies for man to discover? Would it change our way of living?

In the next few pages you will read about the supplies of minerals that are stored away in the earth. Perhaps you can decide how we can help to see that these supplies are used wisely.


SALT



Galloway

An electromagnet is unloading scrap metal. This scrap will be used again in making new steel produ

Man Wastes Valuable Materials

Many thousands of tons of metal ores are wasted because mineowners cannot afford to work the poor grade of mineral ores. Mines are often left to fill with water when only the rich ores have been worked. The wooden shafts and pillars that have held up the roofs of the mines finally come crashing down, dragging huge piles of ore and rock with them. This waste is taking place in hundreds of mines in the world. Underneath these piles of rotting timbers and water lie hundreds of thousands of tons of ore that may never be used again. It is very dangerous and expensive to restore an old mine that has been left to crumble and fill with water.

The world of tomorrow may have to depend entirely upon these poor ores, unless we try to make it worth while for the mineowners to remove all the ore in their mines before they move on to pick the most precious ores out of other mines. This is why people who are looking ahead into the future are asking the question "How can we stop wasteful mining?"

Sixty-eight of the ninety-two elements that are found in the earth are called metals. Only about one half of these metals are very important to us. In this group of important metals, seven are used more widely than the others. They are iron, copper, aluminum, lead, zinc, gold, and silver. Can you think of some of the uses of these seven metals? If these seven precious metals are not wisely used, they will be gone forever; and the first of them to disappear are likely to be those that are most scarce.

m three to five million automobiles make their last trip to the junk yard every year

Fortunately for us metals are not gone forever when they are used once. When a ton of coal is burned, it is changed into a ton of ashes and gases, and it can never be burned again. A ton of metal can be used over and over again.

We should not need to think much about saving our mineral supplies if new supplies were being made in the earth today. But it is not likely that many mineral resources are being made in the earth at present. The mineral resources we use today were probably formed millions of years ago.

The minerals in the earth's surface are not spread out evenly. Some countries have large mineral supplies, while other countries have not nearly enough for their own needs. North America happens to be very rich in most mineral resources. Minerals do not rightfully belong to any one nation or to any one group of people. It is the right of every child born today and in the future to have these minerals to use. But if the children of the future are going to have them, we must learn to use them wisely.

Man has not always had much use for minerals. During the past thirty years the world has used more of its mineral resources than it has since the beginning of history.

The largest waste of metal today is taking place in huge junk piles containing old automobiles. From three to five million automobiles take their last journey to the junk pile every year. Not all of the metal in these old cars finds its way back to the metal mills. Much of the metal rusts and crumbles. Over five million tons of metal crumble into dust in this way each year and can never be used again.

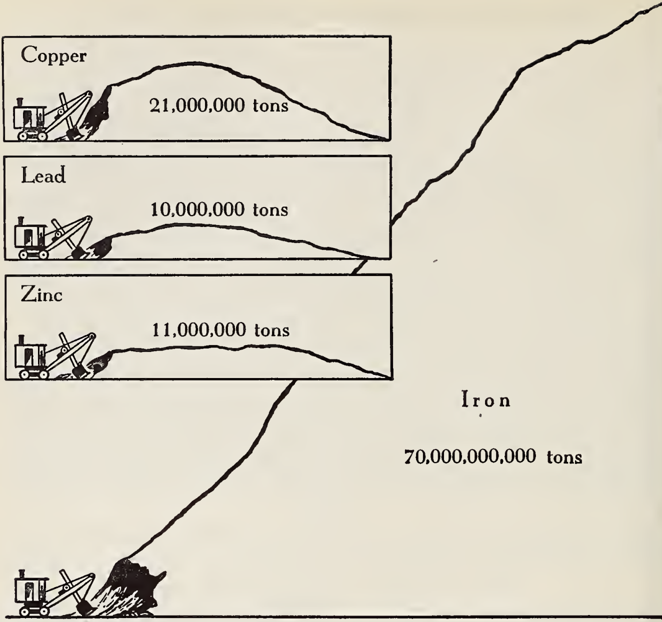
No one knows exactly how many tons of metal ores lie buried in the rocks of the earth. We know that when the supply that is in the earth is gone, nearly one half of the wealth of the world will also be gone.

We Live in an Age of Iron

Perhaps you have heard people say that we are living in the Iron Age. Do you know why they say this? It is because we use iron so much. Nearly 70 per cent of the materials we are using for building are composed of iron, steel, or some iron alloy. In recent years much of our iron ores has been made into iron alloys. About fifty years ago steelmakers began to alloy, or heat, iron with other metals. They discovered that such alloys sometimes served their purpose better than iron or steel. One of the most common of the elements used in alloys is manganese. If seven pounds of manganese are mixed with one thousand pounds of white-hot steel, the steel is made stronger. If more manganese is added, the steel is made so tough that it can be used for the teeth of steam-shovel

Shovel loading ore at open iron mine

Schach from Nesmith



Probable amounts of these minerals still unmined in the United States. How long will they last? That depends upon how wisely we mine them

dippers, which tear huge holes in the surface of the earth. Did you ever see a steam shovel digging away at the earth? Did you think how tough the teeth of the shovel must be?

Iron happens to be one of our most common metals. But much of the iron in the earth cannot be used at the present time. The rocks near the surface of the earth have only been scratched with the shovel and the drill. The part of the earth sometimes called the crust is about forty miles deep. The distance, as you know, to the center of the earth is 4000 miles. The deepest hole that has been made in the earth is less than

three miles deep. Sometimes men have wondered if they could make deeper mines and go down farther than three miles. In this way, they thought, they might obtain greater supplies of minerals. The machines and labor needed to make such deep mines would be very expensive. Then, too, the great pressure of the rocks above such deep mines would make the mining very dangerous. Yet many millions of tons of iron and other useful metals lie beyond the reach of the shovel and the drill.

However, there are still large stores of iron within the three-mile limit. Some of this iron is being used today, but much more is being passed by. Miners say that some of it is not worth working. Miners call rock an ore if it contains enough of a mineral to make it practical to mine it.

How long will the supply of rich iron ore last? That will depend almost entirely upon the people who are using it. If we continue to use as much iron as we have in the past fifty years, our supply of this metal may last only one hundred years. But we who are using it can make it last much longer if we will help to conserve it.

Our iron supply will probably last for many years to come if we learn to use it wisely. One billion tons of iron have been used in the United States since colonial days. Three hundred million tons of this metal have been lost by allowing it to rust, by burying it in the ground in the form of pipes, and by manufacturing it into articles from which the iron cannot easily be removed.

Several million tons of iron and steel crumble into rust each year. Iron rust is a compound which is formed when iron lies open to air and moisture. At present we consider iron rust a waste that can be prevented by coating the iron or steel with materials that will not corrode, or wear away

© Douglas from Gendreau

Operating with a drill in a copper mine

as by rusting. Every year corrosion, or the wearing away of metals that lie open to air, costs the world five billion dollars. Part of it is spent in using varnishes and enamel. Because this kind of coating does not last very long, iron and steel are often coated with tin or aluminum. In some cases iron is mixed and melted with other metals that help to prevent rusting. This mixture is called an alloy.

Many of our kitchen utensils are made of stainless steel. Stainless steel is an alloy containing iron, chromium, and nickel. In some cases metals, such as bronze and copper, that do not corrode so easily are used in place of iron and steel. Because we are learning to care for articles made of iron and steel, we can expect that the loss of this metal from corrosion will become less and less.

At the present time more than half of the metal going into a steel furnace is scrap iron. Steel supports from office buildings that have been torn down, old railroad rails, steamships that can no longer be used, and old automobiles are sold as scrap. This scrap is sent to steel mills. Later this same steel may be used in building bridges, locomotives, office buildings, refrigerators, and other iron and steel articles. Some articles made of steel and iron cannot be used as scrap as yet, because we do not know a practical way to remove the copper, tin, nickel, tungsten, and other alloys from the scrap. When a way is found, even more scrap iron will be used.

We may use less and less iron and steel in the future, because we shall not have to replace our bridges, locomotives, rails, automobiles, and other steel articles so often. Steel is being rolled into thinner sheets that stand more strain and wear than the thicker sheets of the past. Today it is possible to build the frame of an airplane out of steel because it is so light and strong. Fenders on automobiles are being built thinner and thinner, and yet they are stronger than the heavier fenders on the first automobiles. Steel structures are going to weigh less and last longer than they have in the past.

Because we are learning to use iron wisely, and because we are going to remove smaller and smaller amounts of it from the earth in the years to come, it seems very possible that there will be enough iron for many centuries.

But what about the other metals that we are using so commonly? If we continue to mine copper as we have in the past, our present copper supply will be used up in about thirty-six years. This means that all the copper that our miners consider practical to mine at present will be used in less than forty years if we keep on using it as rapidly as we are today. However, there are large amounts of copper ore of poorer quality that will be practical to use when a better way to remove the ore is discovered.

The world's copper scrap pile has been called the largest copper mine in the world. In the past much of our scrap copper corroded or crumbled into dust. But in recent years we have taken better care of this metal. More than 60 per cent of the copper produced is being made from scrap metals. The use of scrap metal is a very important means of conserving or using our mineral resources wisely. It means that less copper is taken from the mines. However, as the use of scrap metal has increased, many miners have been able to work only part time and some of them have had no work at all. If our mineral resources are to be used wisely, we can expect even more mines to close in the future.

There is sixty times more aluminum in the rocks near the surface of the earth than iron. For this reason it would seem that aluminum might be used more commonly than it is today. We should also expect it to be cheaper than iron. This is not the case. Iron from the blast furnace is much cheaper than aluminum. Many of the ores containing aluminum cannot be used at present because we do not know a cheap way to remove the aluminum. Even if a better way is found, it is probable that aluminum will never be sold so

		PRIMARY ORE PRODUCTION	SECONDARY ORE PRODUCTION	Percentage of secondary ore used
Copper	1916	944,376 tons	350,000 tons	27%
	1938	562,328 tons	359,800 tons	64%
Lead	1916	552,228 tons	96,300 tons	17%
	1938	331,964 tons	224,900 tons	67.6%
Zinc	1916	564,348 tons	129,200 tons	20%
	1938	436,007 tons	179,821 tons	41.6%

Every year more and more scrap metal, or secondary metal, is used and less and less of the primary ore is mined

cheaply as iron. It requires a great deal of heat to remove aluminum from the ore. But when a new way is discovered, it will mean more work and more things for the people.

We know that the supply of lead and zinc in the earth is small. And very little of these minerals can be returned to the furnaces for scrap metal. Much of the lead produced is made into articles that are very hard to save. One fourth of all our lead is used in making white paint. After a while lead flakes off and falls to the ground and the building needs more paint. A large amount of lead is also used in antiknock gasoline. The best way to save this metal would be to use other minerals that are not so scarce, whenever it is possible.

Less zinc scrap is used than lead. About one fourth of the zinc produced also goes into paint pigments. About one half of the zinc produced is used in coating iron and is seldom returned to the mills as scrap metal.

Panning gold. Methods like this one have been used for many years

Gold and silver are two of the rare metals that are never likely to disappear from the earth, because they are used very carefully.

Most of the gold produced today goes into our treasuries or vaults, where it does not have the wear that most other metals have, and where it is not likely to be lost.

Although the loss of produced gold is not very great, there is still a considerable amount of waste occurring in the mining of gold. Years ago methods used in gold-mining were not so good as they are today. During that time only a very small amount of the gold was removed from the ore. Many tons of ore still containing gold were dumped into streams. This ore was washed away and may be lost forever.

Metalworkers call ore from which some of the metal has been removed tailings. In many mills today these tailings are stored in piles awaiting the time when improved methods will make it possible to remove the remaining metal.

Silver is like gold in that it also is a precious metal, because it is valued so highly. Silver coins are still used in many countries. Because this metal is usually found in ores with gold, it has been wasted in much the same manner.

The greatest demand for silver today is for films and prints made from films. Much of the silver used in this way is lost, because a small studio cannot afford to remove the silver from old negatives and prints and use it over again. In large concerns that develop films the silver is recovered. Silver losses resulting from the developing of films and prints are very great and may become greater as the demand for motion-picture and camera supplies increases.

Man Needs Mineral Resources That Are Not Metals

There are many different kinds of mineral resources in the rocks near the surface of the earth that are not metals. For this reason these minerals are often called nonmetallic. Many of these nonmetallic minerals are equally as important to us as the precious metals, even though we do not use such large amounts of them. Without these nonmetals it would be impossible for us to continue to live as we do today. Some of the most important are sulfur, chlorine, asbestos, graphite, mineral fertilizers, limestone, and marble.

Sulfur is a very widely used nonmetal. A sulfur compound called sulfuric acid is used in producing chemicals, oil, and metal objects. Although there are large supplies of sulfur in the world today, we are removing sulfur more rapidly than necessary. The large deposits of this mineral in Louisiana have almost been removed. However, there are still large amounts of sulfur along the gulf coast of Texas.

Next to sulfur, chlorine is probably the most important nonmetal to industry. The world's supply of chlorine is made from salt. Salt is a compound containing sodium and chlorine. The chlorine is removed from salt by passing a current of electricity through salt water. Hydrochloric acid contains chlorine. Hydrochloric acid is used in manufacturing cloth and paper.

There seems to be little chance of our using up the world's supply of salt. There are many billions of tons of it in salt wells and lakes. When this is gone, there are many more millions and millions of tons in the ocean.

Although the United States has rich supplies of some

minerals, there are some that are lacking. Two of these minerals are asbestos and graphite. There is very little asbestos in the United States that is usable at the present time; but Canada has a large supply of it. By exchanging mineral resources, Canada and the United States will probably always be able to get most of the minerals that they need.

It would seem very strange to the school children if there were no graphite. Graphite is a very soft, shiny form of carbon. Our "lead" pencils are made of this material. However, it has many more uses which are probably even more important. It is used in oils or greases for machines, in paints, and in stove polishes. Although the United States uses more graphite than any other nation of the world, it produces very little of it. Most of our graphite is imported.

If school would seem strange without graphite, think how strange it would seem if we had to worry about collecting enough minerals for next year's food crop. It is true that plants make all the food there is in the world; but they must have raw materials for making it. Part of the materials used by plants are minerals, or fertilizers, such as nitrates, phosphates, potash, and calcium. Since the plants which we harvest take these minerals from the soil, we have to put them back into the soil if we wish to grow more plants.

Fortunately the world is well supplied with fertilizers, and there is no real danger of our supply being used up if nations share these mineral resources with one another.

Almost everywhere we look we find some of our mineral resources or some other country's resources being used. Some of these minerals are so important to us that we cannot exist without them. Others make our living easier, and still others add beauty to our homes and surroundings.

Limestone and marble are beautiful minerals that are often used for building purposes. Perhaps the world's supply of beautiful marbles and limestones will be removed from the earth in a few hundred years. But our supply of lime materials, sand, and gravel used in making cement is found in great quantities all over the world. We shall never lack these materials; and in the future we may be able to make building stones equally as beautiful as some of the rare marbles and limestones.

THINGS TO THINK ABOUT

1. Why was so little iron and steel used before the invention of the steam engine and the gas engine?

2. Some of the iron and steel objects you are using may contain metal that has been in use before.

3. Why do people often cover iron cooking utensils with grease before they put them away?

4. Why did the use of copper increase after the invention of the electric lamp?

5. Very few iron, copper, zinc, lead, and silver mines have been discovered since 1910. In the future many new deposits of these ores may be found.

6. Articles made of pure iron will not rust so easily as articles made of steel. An iron compound forms on the outside of articles made of pure iron and protects them from air and moisture.

7. The wearing quality of an automobile tire depends partly on the minerals added to the rubber.

8. What mineral resources are near your home?

9. What mineral resources are used in wars? Why should not man waste these resources in wars?

10. Why should different regions exchange valuable minerals?

11. A few years ago when men were trying to work some African gold mines at the depth of one mile, they had to stop work because the mines were so hot that the miners suffered from the heat. To-

day mines at the depth of 8300 feet are being worked very successfully. These mines are air-conditioned. It seems very likely that in the future men will find a way to work mines even deeper than this.

THINGS TO DO

1. Examine the edges of a "tin" can. Can you see where the coating of tin ends?

2. Visit a junk dealer and find out what he does with scrap metal. Why are junk dealers doing an important service for your country?

3. Try to obtain some of the ores of our most useful metals and nonmetals.

4. Try to find out where our supplies of useful minerals are deposited.

5. Read some of the stories that have been written about the methods of producing minerals.

XI

How Man Is Learning to Use Power

MAN LEARNS TO USE POWER

MAN GENERATES ELECTRICITY

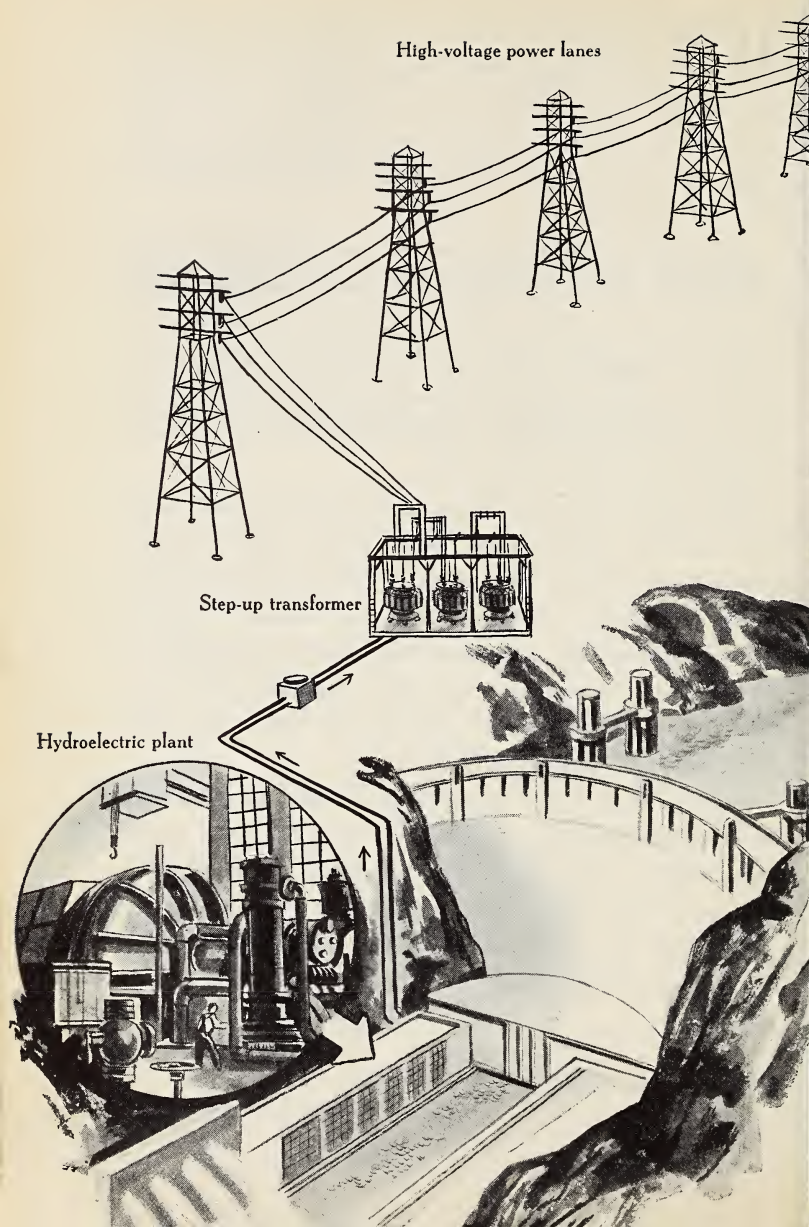
BEFORE the Stone Age, human beings lived much as other animals do today. They hunted for food during the day and found shelter in caves at night. At first they were forced to live in climates where the sun's heat kept them warm, and where food was plentiful in all seasons of the year.

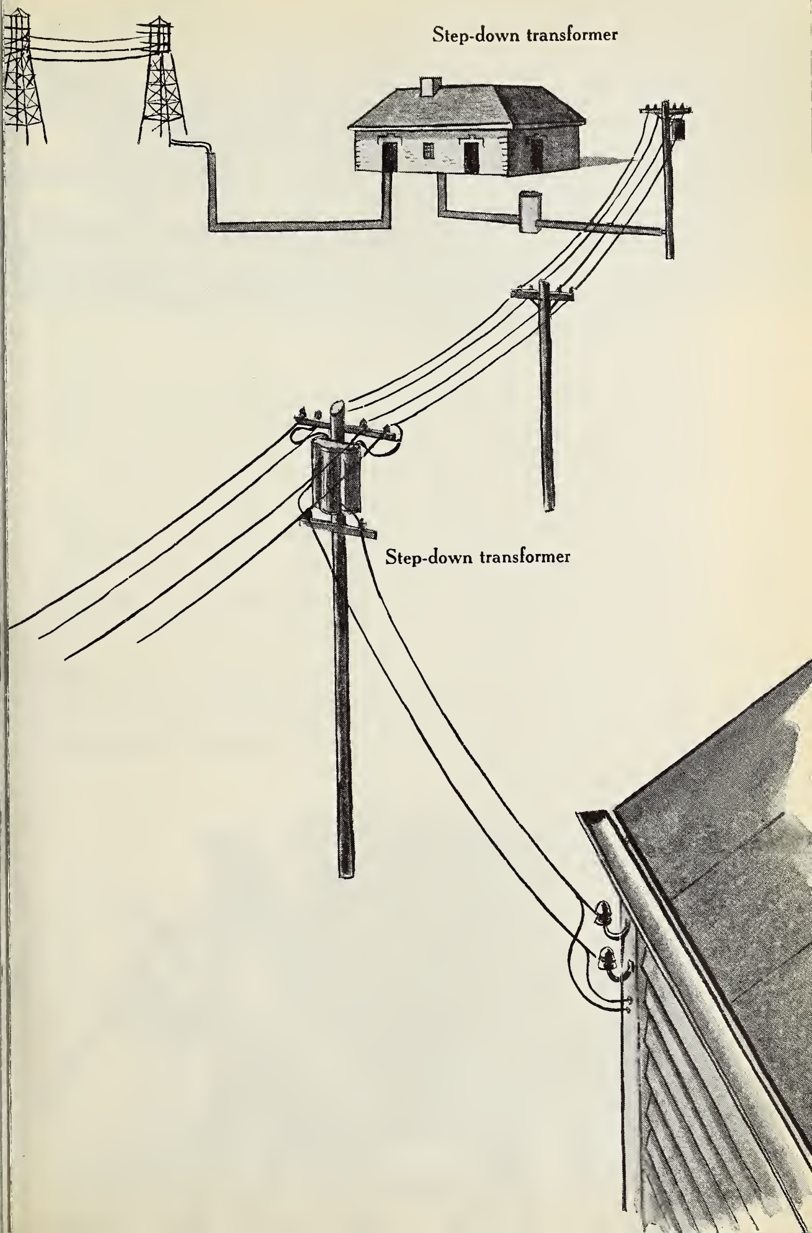
But as they continued to live on the earth they learned how to use more and more of the things around them to make their lives easier. Fire was discovered. Fire made it possible for people to live in the coldest climates on the earth. By using weapons and tools it was possible to get food, clothing, and shelter in much less time than it had been possible to get them in the past.

When plants and animals were domesticated, people could give up their wanderings in search of food. Fairly permanent homes could be built, and the lands surrounding the homes were used for raising plants and animals. As farms developed, machines were invented which were helpful in planting and harvesting crops. Men discovered that animals more powerful than themselves could be used to haul their loads and plow their fields.

As easier ways to live were discovered, men had more time to think, experiment, and discover. They invented many new machines. The invention of machines caused them to feel the need for more and more power.

In this story you will read about how men are discovering and learning to use power.


High-voltage power lanes
Step-up transformer
Hydroelectric plant


Step-down transformer
Step-down transformer

Man Learns to Use Power

MAN LEARNS HOW TO USE ANIMAL POWER

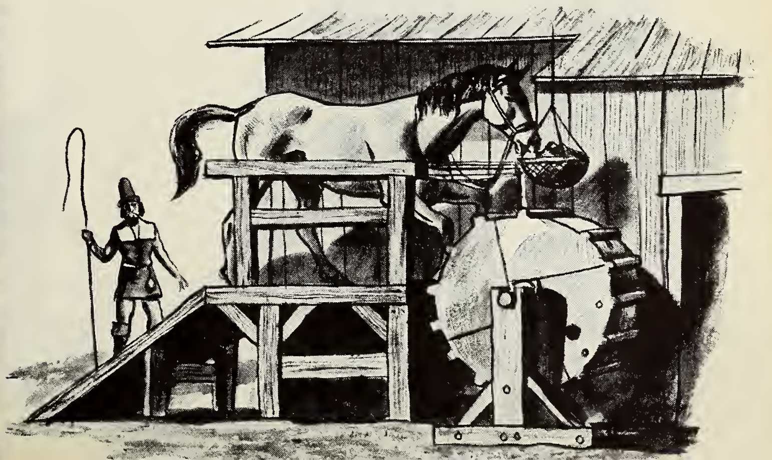
Human beings lived upon the earth for thousands of years before they discovered that animals could help them to do their work. The men of the Stone Age dragged the animals they killed for food long distances back to their cave homes. They strained under their efforts to move large rocks out of their cave entrances. They staggered under the weight of the heavy loads of wood they carried to throw on their fires, which they probably kept burning day and night.

These men of the Stone Age ate horses for food. It never occurred to them that they might use a horse or some other animal to carry their loads. Men raised cows for their meat and their milk, but they never thought of using them for plowing their fields.

The men of the Bronze Age were probably the first to use animals to haul their loads. No one really knows how it was discovered that animals could make work easier. It may have happened in this way:

Perhaps, one day, as a Bronze Age man was driving his herd into a new country, he may have become very tired and removed his pack to rest awhile. As this ancient man was resting, he may have laughed at his own foolishness. Why should he carry the pack when any one of his sturdy animals could carry it so much more easily than he could? When a Bronze Age man placed the first pack on one of the animals in his herd, the age of power began.

Horses worked on tread mills that furnished the power to grind grain



It is likely that only a few years passed before cattle were used for plowing. At first cows were used for farm work.

Later men learned to use only the male cattle, or oxen, to work in the fields and haul heavy loads. Oxen have greater strength than cows, and they are free during the whole year to work. Cows must spend several months a year raising their young.

Oxen and asses were used for hauling loads long before horses. Oxen are much stronger than horses, but they are not so speedy. About three thousand years ago the shepherd kings of Syria brought the first horses into Egypt. Not long after this time horses were harnessed to chariots. In ancient times, however, horses were usually used to carry messengers or warriors.

A native in Libya, North Africa, is plowing a field for a grain crop

Burton Holmes from Galloway

In the seventeenth century horses were used in Europe for heavy work. The English found them very useful for working the machines that pumped water from their open-pit coal mines.

In different countries different kinds of pack animals were used for many centuries. The people of India used elephants. The camel carried the Arabs across the desert. The Indians who lived in the highlands of the Andes trained the llama to do their heavy work. The natives of southern Asia rode horses and harnessed asses to the plow and the wagon. The Chinese used the water buffalo to work in the rice fields.

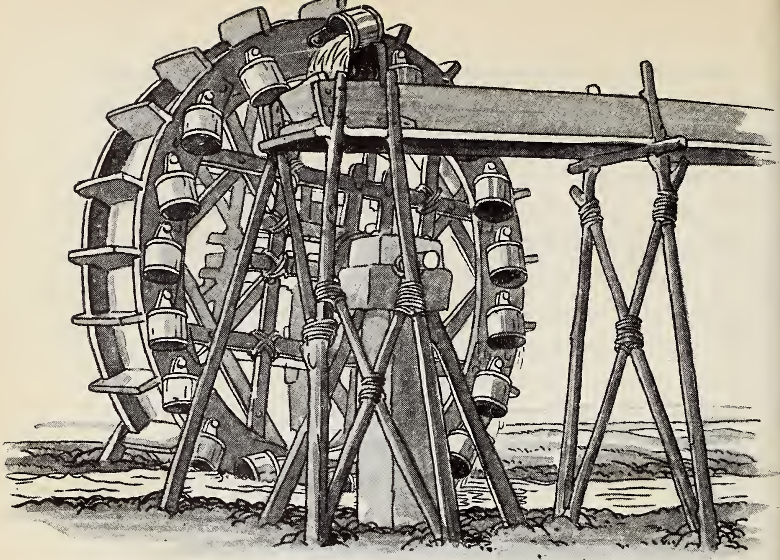
Even today in places where railroads have not been built and travel by water is impossible, horses, asses, yaks, dog teams, camels, and elephants are used to carry freight and passengers. Animal power is still used for many different kinds of work.

MAN USES WATER POWER

Several thousand years ago men were depending almost entirely upon themselves or animals to work in their fields and grind their grains. But even then some people had already discovered that there was another kind of power.

The Egyptians used a water pump called a noria for irrigating their lands. The Egyptians built norias, or water wheels, of many different sizes. Norias are called undershot water wheels. The force of running water striking against the lower part of the wheel made the wheel go around.

These ancient water wheels had several buckets fastened to their rim. The buckets filled as the wheel turned through the water. Every time the wheel turned, the top bucket struck against a bar, tipping the water into a gutter.



An undershot wheel

More than two thousand years ago water power was used to grind corn and other grains. The Norsemen built water wheels that lay flat in the water. They liked this kind of wheel because it could be fastened to millstones more easily than the noria, and it could not be seen by enemies. The Norsemen knew that if enemies destroyed their water wheels there would be a shortage of food.

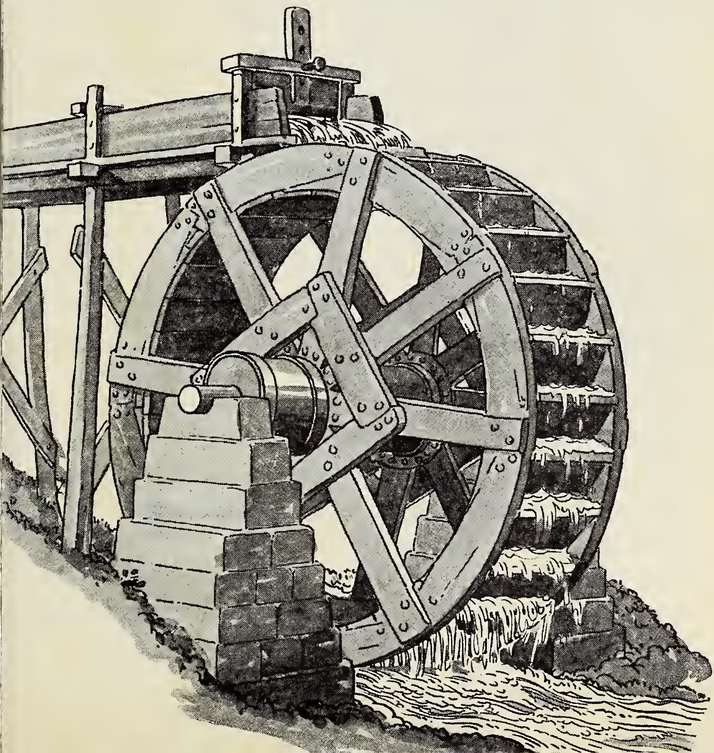
However, people in other countries liked the undershot wheel better even though it could be used as a target by enemies. The undershot wheel could do so much more work than the Norsemen's water wheel. The Norsemen's water wheel splashed and churned the water, but it did very little work.

The Romans built their grinding mills on flat-bottomed boats, or barges, in the middle of swiftly running rivers.

They built an axle across the barge and fastened an undershot wheel on each end of the axle. The rivers furnished the power to turn the wheels, and the wheels turned the millstones that ground their grain.

At first the Romans anchored their mills in the widest parts of the rivers. Later someone discovered that the smaller streams had more power than the rivers. After the ancient millers heard about this important discovery, they began to look for narrower and swifter streams in which they might anchor their mills.

An overshot wheel



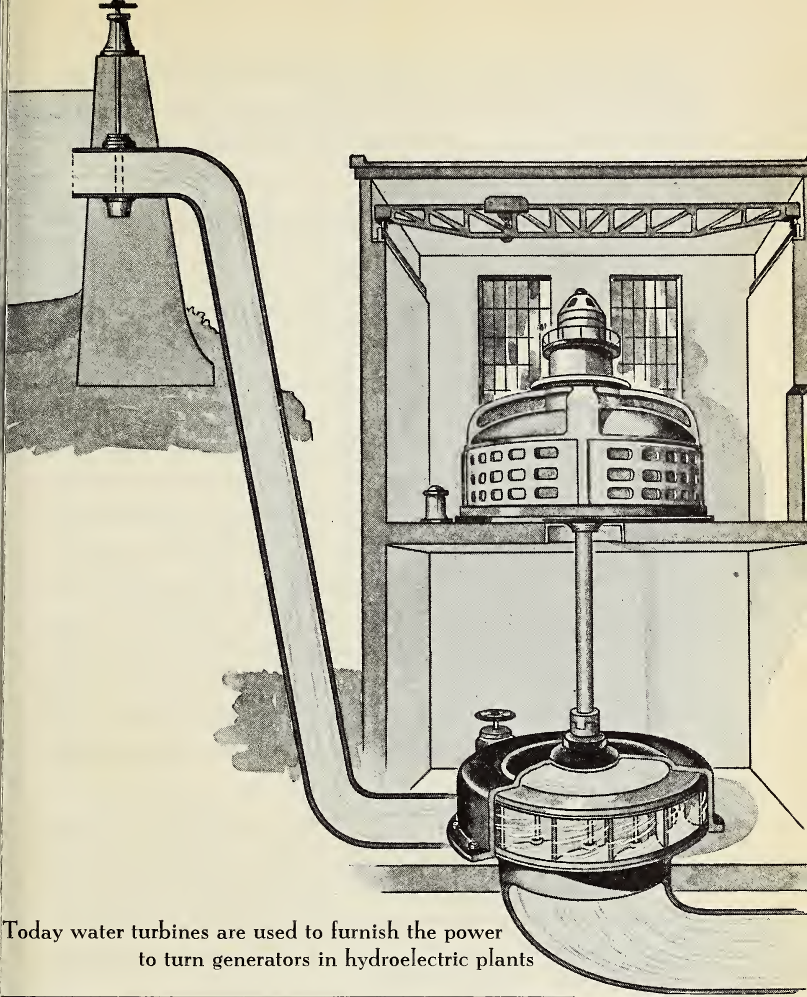
The barges of the Romans may have been grounded many times on the bottom of the narrow streams before they thought of building mills on the shores of these streams. But once this had been thought of, mill barges disappeared from the middle of streams and tiny grinding mills appeared along the shores.

Not long after this time some clever Roman made another discovery. He built a wheel very much like the undershot wheel, but instead of having the buckets fill at the bottom, he placed the wheel so that running water filled the buckets at the top. The weight of the water in the top buckets forced the wheel around. As the wheel turned, the water spilled out at the bottom. This kind of water wheel is called an overshot wheel, because the force that turns the wheel operates from the top.

Overshot and undershot wheels ground grains for many centuries before any important changes were made in them.

About one hundred and fifty years ago the British began using a new kind of water wheel called the water turbine. River water ran through a canal into small pipes leading from the walls of the canal. These pipes carried the water directly to the blades of a water wheel which lay in a tightly fitted metal cover. When water flows through small pipes it has more force than it has when it is flowing in a wide river bed. For this reason the water turbine could be used in streams where the water did not have enough force to turn overshot and undershot wheels. The water turbine was a very important invention to people who lived at this time. This kind of water wheel made it possible for them to use more streams for water power.

In the nineteenth century undershot wheels, overshot wheels, and water turbines were used for doing many differ-



Today water turbines are used to furnish the power
to turn generators in hydroelectric plants

ent kinds of work. They were used for grinding grain, sawing logs into lumber, running machinery in factories, and operating the bellows that fanned the flames in the open fireplaces, or forges, of iron mills.

Even today many sawmills, clothing mills, and grinding mills, built along the edges of streams and near waterfalls, depend upon water power to run their machinery.

MAN USES STEAM POWER

Sometime during the first century A.D. Hero, a Greek, discovered another kind of power. Hero learned that he could change liquid water into steam and that this steam had force, or pressure. Hero invented the first steam engine; but he did not use it to do work; he thought it was only a toy.

The engine consisted of a metal globe with a tube on each side. He poured some water into the globe and heated the water until it boiled. After the water boiled, it changed into steam. As the steam rushed out of the tubes, it pushed against the air. The force of the steam pushing against the air made the globe whirl around. Hero must have been very proud of his toy. He showed it to many of his friends, who also enjoyed watching it whirl around. But no one paid much attention to Hero's discovery, because at that time people thought water wheels could furnish the necessary power.

More than eighteen hundred years passed before steam was used to do work. In the seventeenth century the open-pit coal mines in England were being sunk deeper and deeper into the ground. As the mines were sunk deeper and deeper, water collected in the pits. If the mines were to be worked, a machine was needed to pump out the water.

For this reason people became interested in steam. They tried many experiments. Several engines were made, but they did not work very well. Thomas Newcomen invented the first steam engine that was really useful. This steam

engine was used for many years. The Newcomen engine consisted of a firebox, a cylinder that had a steam and a water valve, a piston, and a rod. A cylinder is a round metal tube in which the piston moves. These two parts look like a bicycle pump. A valve is a device that opens and closes an opening into which steam or water flows. The piston is a metal disk that is made so that it can slide in the cylinder. When steam pushes the piston, the rod which is fastened to one end of the piston moves the parts of the engine that are connected to the rod. Steam pushed the piston up in the Newcomen engine, and air pushed the piston down again. In those days small boys were hired to open and close the steam and water valves. The Newcomen engine was used for more than seventy-five years.

In 1764 James Watt was asked to repair one of the Newcomen engines. As he worked on his repair job, he wondered why the steam in the cylinder could not push the piston downward as well as upward. In order to make the steam push the piston both ways, Mr. Watt had to invent an engine that could get rid of steam at the top and at the bottom of the cylinder.

Day after day for many long months Watt worked on his engine. It was a harder task than he had realized. But at last he succeeded in making the first engine in which steam pushed a piston both ways.

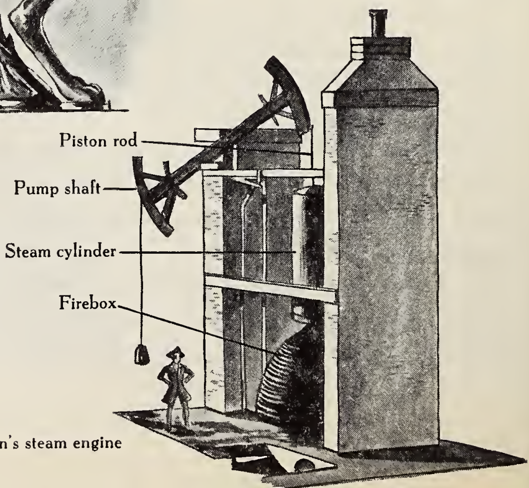
Steam entered the cylinder through two steam valves, one at the top of the cylinder and one at the bottom. A sliding metal arm, or valve, opened and closed the steam valves. First the steam rushed through the bottom steam valve and pushed the piston upward. Then the sliding valve opened the top valve, and steam rushed in and pushed the piston downward again. The steam that had done work pushing

the piston was forced out of the cylinder through openings that led into a cooling cylinder. In this cylinder the steam was cooled. Modern steam engines are built very much like the first Watt engine.

During the latter part of the eighteenth century many factories were still using the water power furnished by small streams. These factories were often closed during the summer months because there was not enough water to turn the

Some of the first steam engines looked l
not do so much work for the amount

Hero's steam engine



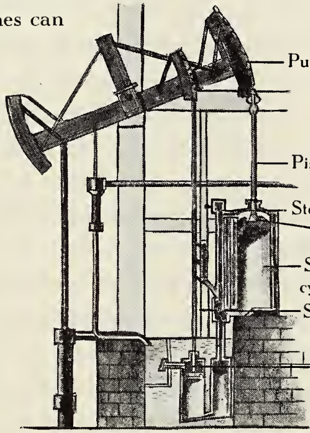
Newcomen's steam engine

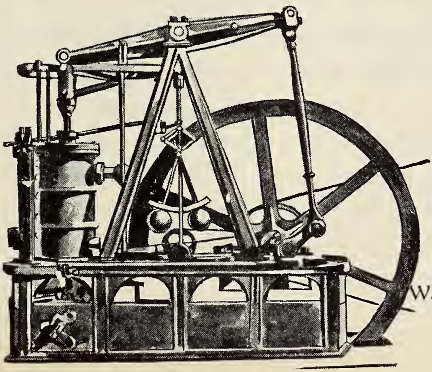
water wheels. An engine was needed that could pump enough water to keep the wheels of these factories turning.

In 1773 Watt built a steam engine that could be used for this purpose. But as soon as the rains fell in the fall, the wheels turned once more by water power and the steam engines were stopped. In those times men could not afford to run steam engines when they could use water power, because steam engines used coal, which was expensive.

shown in the picture. They could
ɔurned as modern steam engines can

Watt's first steam engine (1767)





Watt's last steam engine (1800)

Twenty years later Watt discovered that he could make an engine that was cheaper to operate. One day while he was working on an engine, he happened to close the steam valve before the piston moved to the top of the cylinder. He was amazed to see that the piston continued to move after he had closed the valve.

Watt began work at once upon another engine. He placed another valve on the cylinder of this new engine. This valve closed the steam valve when the piston moved one fourth of the way through the cylinder. The new Watt engine used about one fourth as much coal as the old one and did about half as much more work.

After Watt had completed his new steam engine, he began to think about another engine that could be used for doing many different kinds of work. He was hoping to use steam for even greater work than pumping water out of coal mines. He believed that he could build an engine with enough power to turn the wheels of grinding mills, sawmills, and machinery in clothing mills as well.

When Watt told his friends about his new idea, they urged him to set to work at once. In a few months the new engine was ready to use. This new steam engine could be used to turn the wheels of many different kinds of machines.

Years have passed during which the wheels of machines have whirled around and around helping men to do their work. Many of these machines get their power from engines that are like Watt's steam engine.

MAN USES THE ENERGY FROM ANOTHER KIND OF EXPANDING GAS

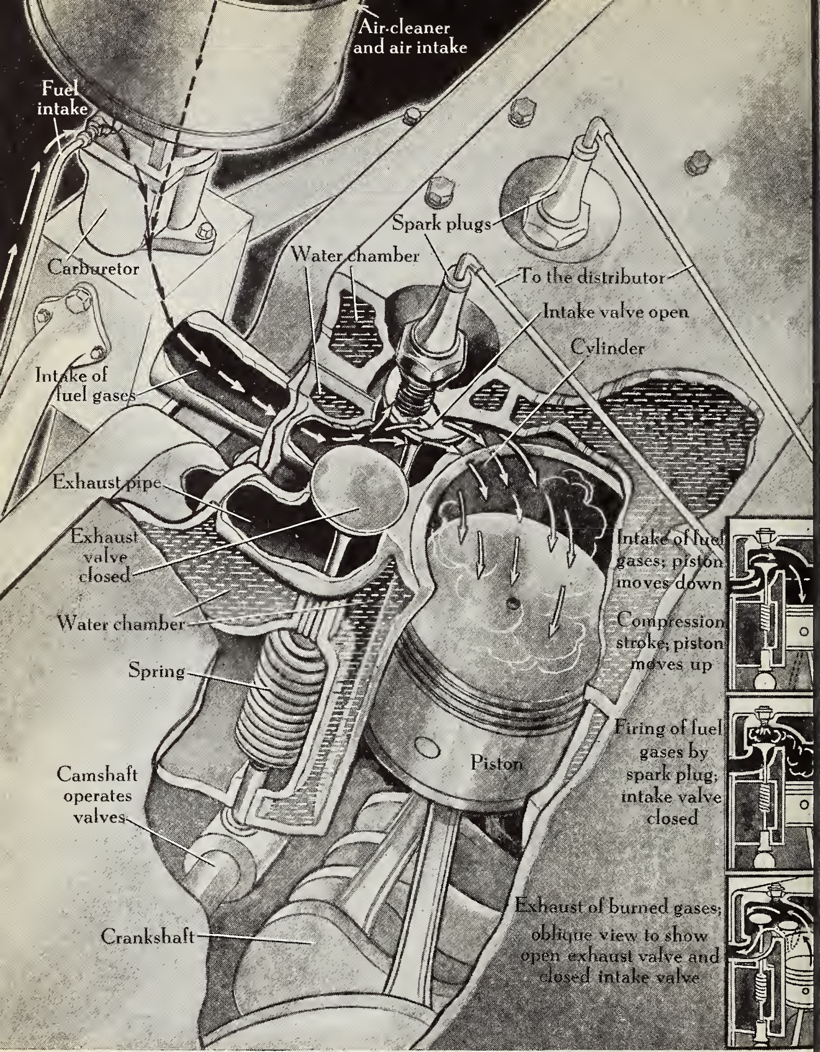
Great discoveries are often made by people who are not satisfied with things as they are and try to improve them. Toward the close of the nineteenth century men were beginning to be dissatisfied with steam engines. They wanted to build an engine that would use less fuel. They thought this could be done by building an engine that burned fuel in the cylinder.

This was not the first time that men had dreamed about this kind of engine. Other men had had the same idea. Christian Huygens, in the seventeenth century, had said that the expanding, or spreading out, of gas from gunpowder might be made to do work. He suggested placing the gunpowder beneath the piston in the cylinder of an engine.

Christian Huygens probably got his idea as he watched a cannon being fired. Cannons were really the first machines that used the force, or energy, of expanding gas. A cannon works very much like a gas engine. The piston in a gas engine is like the cannon ball in the cannon. The cannon uses the force of expanding gas from gunpowder to push the cannon ball. The gas engine uses a mixture of expanding gasoline vapor and air to move the piston.

Although gunpowder engines were made in the seventeenth century, most people did not use them. Gunpowder engines were very apt to blow into pieces as the gas from the gunpowder expanded. For this reason interest in this type of engine grew less and less.

When coal gas was discovered, men tried again to invent an engine that could burn gas in the cylinder. Several engines were invented; but none of these engines were very successful.



The parts of a gasoline engine

Nearly eighty years passed before a useful gas engine was made. This gas engine was invented by Otto and Langan, two German inventors. These men built a gas engine that worked very much like a steam engine. A steam engine uses the force of expanding steam to push the piston. A gas engine uses the force of expanding gasoline vapors and air to push the piston.

There are several reasons why men began to use more and more gas engines and fewer steam engines. Gas engines are cheaper to run, because they do more work with less fuel. The piston in a gas engine makes two backward and two forward motions before more gasoline vapors and air enter the cylinder. The piston in a steam engine uses steam every time it moves backward and every time it moves forward. Gas engines do not waste fuel in heating large boilers and connecting pipes, and they do not burn fuel when they are standing idle.

It is no wonder that some manufacturers removed the steam engines from their factories and mills and put in gas engines to turn their wheels.

THINGS TO THINK ABOUT

1. Although Caesar Augustus had more than four thousand slaves to do his work, he had less power than the average garage-owner.

2. Every minute that gasoline is properly used in a gas engine, it does as much work as several teams of horses could do in that same length of time.

3. The force made by changing a gallon of gasoline into a mixture of gasoline vapor and air and exploding it in a gas engine can do any one of the following things: move a one-ton truck fourteen miles at the rate of forty miles an hour, run machinery to milk three hundred cows; make four tons of hay into bales;

plow three fifths of an acre of land; keep eight electric lights burning for thirty hours.

4. Someone who was interested in finding out how much machinery has helped farmers worked these problems. He found that if a man who owned a farm of six hundred and forty acres began to spade it in 1430, his children's children's children and a great many more of these children's children would have just finished spading it in 1930. How many years would it have taken those farmers to spade that farm? How long would it take a team of horses to do it? One horse can do the work of seven men. A tractor with a gang of plows could plow that field in thirty-six hours.

5. One gallon of water will make 1750 gallons of steam.

6. Humphrey Potter was one of the many young boys who was hired to open and shut the steam valve in the Newcomen engine. One day Humphrey Potter made a very important discovery. He found that by tying a string from the piston rod to the steam valve, the motion of the piston rod would open and close the steam valve. Humphrey Potter discovered that a lever could do his work for him; so he left his work and went off to play. We do not know what was said when the coal-miners discovered that the steam engine was working without a small boy to turn the valve off and on. We do know that it was not long before iron levers were being used to open and close the valves on steam engines. When this improvement was made the Newcomen engine ran three times as fast as it had in the past.

THINGS TO DO

1. With your teacher's help, put some water in a test tube. Place a stopper very gently in the test tube. Heat the water to the boiling point and watch the steam blow out the cork. Why does the steam blow out the stopper?

2. If you have a toy steam engine, see if you can tell just how the steam makes the piston move back and forth. How does the piston move the wheels? Explain to the class how the toy steam engine works.

3. Explain how a gas engine works. Show in what ways it differs from the steam engine.

Man Generates Electricity

MAN MAKES FRICTIONAL AND CHEMICAL ELECTRICITY

More than two thousand years ago as some Syrian women bent over their spinning wheels, they noticed that the whirling spindles, or rods on which the thread is wound, seemed to be attracted to their clothing. The spindles were rubbing against their clothes and picking up small pieces of the fibers. Thales, a Greek, made note of this fact and tried to explain it. He thought that the souls or spirits of people who had died were in the spindles and that these souls were attracted to the Syrian spinners. More than seventeen hundred years passed before men learned why the cloth and the amber spindles were attracted to each other.

By the latter part of the seventeenth century it was discovered that whenever cloth and amber were rubbed together they made a charge, or load, of electricity. This charge of electricity was called frictional electricity, because it was made by rubbing two different kinds of materials together.

In 1670 Otto Von Guericke built the first frictional electricity machine. The machine consisted of a large sulfur ball fastened on an iron rod so that it could turn around, or rotate. When Otto Von Guericke took this machine into a dark room and rubbed the rotating ball with silk, small sparks flew from the ball.

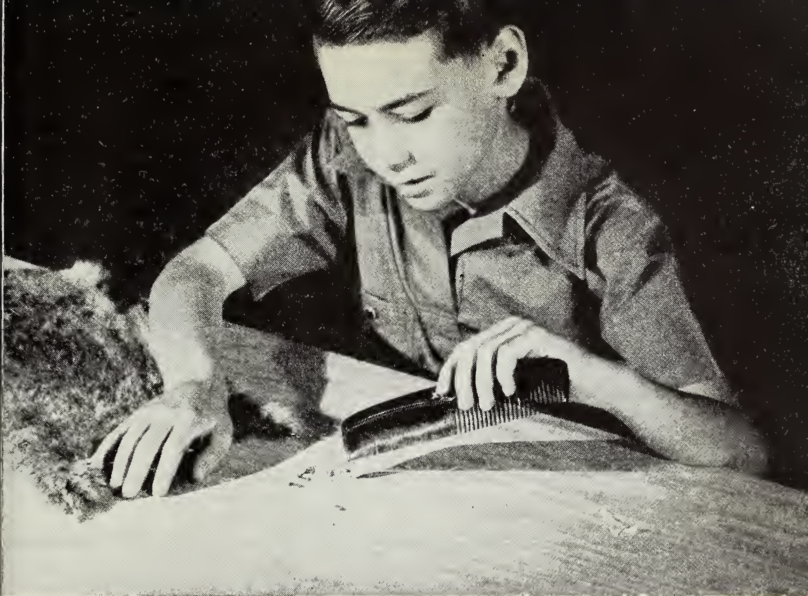
Otto Von Guericke's experiment caused men to think about making large electrical machines. Some men thought that large electrical machines might make electricity to light their homes, churches, schools, and factories. They even dreamed that some day the dark streets of their city would glow with light made by the turning of huge electrical machines.

For nearly two hundred years men worked with frictional electricity. When some of the inventors thought they had made the kind of machine that might prove useful, they would call together a group of people. Sometimes these people went away amazed at the wonderful things that frictional electricity could do. But more often than not they were disappointed. The success of their experiment depended upon the weather. If it was a rainy day, the water in the air carried the electricity away almost as fast as it was made.

Frictional electricity was beginning to be considered a plaything. So people gave up the idea of trying to use frictional electricity for power and started thinking about other things.

Rubbing fur and comb together to make frictional electricity

Wilson

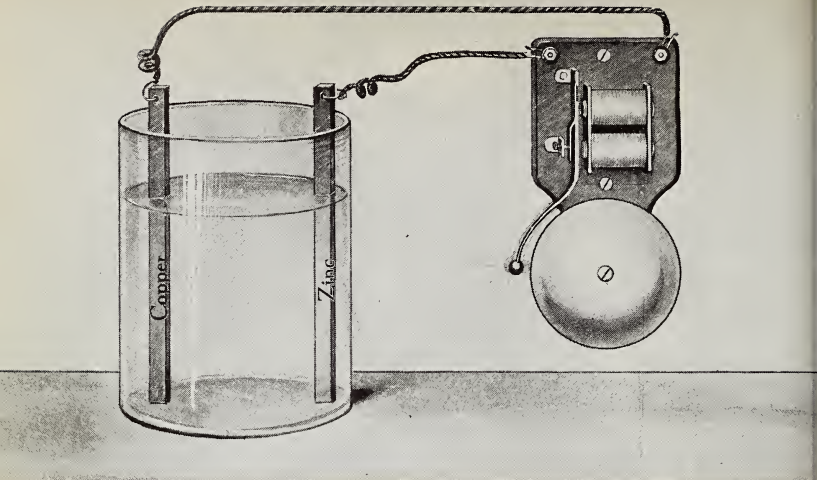


Wilson

Picking up paper with comb that has been rubbed on fur

More than one hundred years passed before another way to make electricity was discovered. In 1786 Alessandro Volta invented the first electric battery. He made his battery out of strips of copper, zinc, and paper soaked in salt water. The salt water together with the strips of copper and zinc produced a very weak current of electricity. He had found a new way to make electricity.

Men were disappointed when they learned that they could not use electric batteries for lighting their homes. It is expensive to use electric batteries. Electric batteries last only a short time, because the chemical that is the substance used soon becomes too weak to make a current. When this happens, more money must be spent for new batteries. Electric batteries are useful for furnishing electricity for a short time.



Making electricity by using chemicals

MAN LEARNS TO GENERATE ELECTRICITY

Volta's discovery once more aroused interest in electricity. Only a few months passed before Hans Christian Oersted discovered that electricity and magnetism are somewhat alike.

A magnet also has a magnetic field around it. This magnetic field is composed of tiny lines of force that cannot be seen. As you probably know, a magnet has two poles, one pole on either end. One pole is called the north-seeking pole because it points to the north when the magnet is hung so that it can swing freely, and the other pole is called the south-seeking pole because it points to the south. The lines of force are believed to move out of the north-seeking pole and to enter the south-seeking pole. It is the lines of force in the magnetic field that attract iron, steel, nickel, and cobalt.

Oersted found that a wire carrying a current of electricity has a magnetic field around it. A young boy, André Marie

Ampère, was present when Oersted showed a group of scientists what he had discovered. Ampère was very excited about what he saw. He hurried home and set to work to see what he could discover.

A few days later he was ready to try his experiment. He hung a coil of wire carrying a current of electricity so that it could swing. One end of the wire swung to the north, just like a bar magnet. When Ampère saw this, he wondered what would happen if he put a soft-iron bar through the coil of wire. He held the soft-iron bar in the center of the coil of wire for a few moments. The soft-iron bar became a magnet!

Ampère had discovered how to make an electromagnet. He learned some of the things you may already know about electricity. He found that if he wound more wire around the iron core the electromagnet would have more force to attract objects made of iron and steel.

This young French boy found out in a week what scientists had been wanting to know for several centuries.

These discoveries caused Michael Faraday, another young boy, to do some thinking and experimenting. He wondered why a magnet could not be used to make an electric current. For years he worked upon his idea.

One day he wound two hundred and twenty feet of copper wire into a coil. He fastened this coil on a wooden frame. He connected the ends of the copper wire to a galvanometer. A galvanometer is an instrument that shows whether a current of electricity is flowing through a wire. He pushed the end of a bar magnet into the coil of wire. When he pushed the magnet into the coil, the needle of the galvanometer moved. As he pulled the magnet out of the coil, the needle moved in the opposite direction.

When Faraday saw the needle of the galvanometer move, he knew that he was forcing electricity through a wire. So he decided to build a machine that could do this.

Faraday began work at once. He cut a large copper disk and fastened it to a brass axle. Then he cut two strips of copper. He placed one strip on the rim of the copper disk and the other on the brass axle. To each of these two pieces of metal, he fastened a piece of copper wire. Then he fastened the other ends of the copper wires to a galvanometer. He called the two pieces of metal that he had fastened to the two copper wires brushes. He hoped that these brushes would "brush off" the electricity when he turned the copper disk between the poles of a magnet. He fastened a crank to the axle of the machine so that he could turn the copper disk very rapidly.

The machine was at last ready for the test. Would it make an electric current flow through the wires? As Faraday turned the crank, he saw the needle of the galvanometer move. This time the needle moved and stayed in the position in which it had moved. The faster he turned the crank, the farther the needle swung.

Faraday was doing something that men had been trying to do for many years. He was making a steady flow of electricity. He was making a stream of electrons, or a current of electricity, flow through a wire. The whirling copper disk cut the lines of force around the magnet. These lines of force had enough power to push electrons through the wire.

As the copper plate whirled faster and faster, it squeezed some of the lines of force together. As the lines of force were cut more and more often, the electrons in the copper plate were pushed harder and harder. As the electrons in the copper plate were pushed harder, they struck against one an-

Wilson

his boy is forcing a current of electricity through the wire by moving the wire between the poles of the magnet

other with more force. This made the current of electricity stronger.

Whenever the copper plate squeezed the lines of force closer together, it made some of the electrons in the copper disk move. These electrons pushed their way out of the copper disk. They shoved their way through the brush on the rim of the plate and into the copper wire. They flowed through the copper wire into the galvanometer. Then the electrons rushed out through the other side of the galvanometer and into a copper wire. This copper wire led back to the axle on which the disk turned.

We call a machine that moves electrons a generator. The electricity used in our homes comes from large generators that work like the one made by Michael Faraday. Instead of using muscle power to turn the generators, men use steam, water power, or the power from expanding gas.

Some of the largest generators in the world are turned by water power. The force of falling water furnishes the power for these generators. Electricity can be made more cheaply by using water power. It would take many millions of tons of coal to produce the same amount of electric power as that made by the huge generators at the Boulder Dam on the Colorado River, or at the Grand Coulee dam on the Columbia River.

Some generators that are being built today weigh many hundreds of tons. Can you imagine how large such generators are? A generator of this size can furnish enough electricity to run three hundred streetcars.

HOW ELECTRICITY FLOWS INTO OUR HOMES

Huge generators furnish many thousands of volts of electricity. A volt is the measure of the push, or force, with which electrons move. But even with all this power, a device had to be invented to help supply all the electricity needed. Some generators make only a few thousand volts of electricity. But the power lines or wires from these generators may carry as much as one hundred thousand volts.

Do you know from where all these extra volts of electricity come? Not far from the powerhouse, there is a station in which the volts are "stepped up" by step-up transformers. These step-up transformers do just what their name suggests. They step up, or increase, the volts, or pressure.

A step-up transformer consists of a coil of wire with few windings and a coil of wire with many windings. These coils are wrapped around the opposite ends of a stack of soft iron plates. In the step-up transformer the electric current made by the generator enters the coil of wire with few windings. The volts are stepped up as the electricity flows out through the coil with many windings.

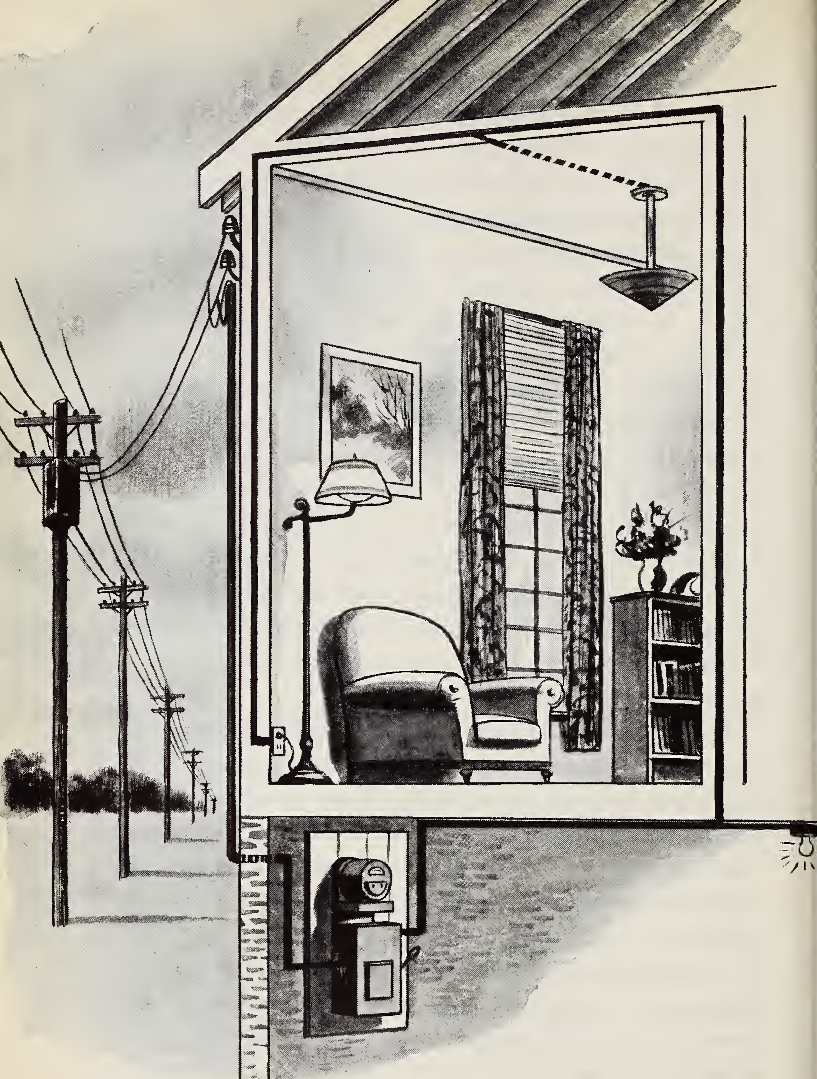
After the electric current leaves the step-up transformer, it travels with great speed through the wires. At the entrance of the city there is usually another station. In this substation the electricity is stepped down, or decreased, by a step-down transformer. The electricity that flows out of the step-down transformer is cut down to a few thousand volts.

You may live in a city where the electricity is carried through wires strung on wooden poles. If you do, you may have noticed small black metal boxes fastened below the crossarm on some of these poles. There are small step-down transformers in these boxes that step down the current to the number of volts needed.

The electricity that flows into your homes may have been stepped down to 110 volts. Two main wires lead from the city power line into your house. These wires are usually placed in a steel cable that is fastened outside the house.

If you follow this steel cable after it enters your home, you will find that it ends at a black switch box. Inside this switch box there is a large knife switch that controls the flow of electricity into your home. When the switch is thrown open, all the lights in your house will go out. When the switch is closed, the electricity passes through the metal blade of the switch into a fuse.

There is a fuse for each circuit in a house. The fuse is a safety device which protects the home against fire. Inside



If you could see the cables that carry electricity into the different rooms of your home, this is the way it would look

the fuse there is a wire that melts more easily than any other wire in the circuit. When the fuse wire melts, there is an open place in the circuit. Electricity cannot get across this open place. The fuse acts as a safety switch. When too much electricity is flowing through the wires, the fuse melts and so breaks the circuit, shutting off the current. So long as there is the usual amount of electricity passing through the fuse wire, everything is all right. Have you ever asked, "What made the fuse blow out?" Either too much current was used by too many electrical appliances or else there was a short circuit.

Sometimes a short circuit is caused by bare electric wires touching each other. The wires in the home are insulated very carefully, but when they are used a great deal, the insulation may wear off, and two wires may touch each other. If two wires touch each other, the electricity goes from one wire to the other without going through the electric iron or whatever the appliance may be. Electricity takes the shortest path back to the switch box; that is why it is called a short circuit.

When there is a short circuit, there is too much electricity passing over the wires. This makes the wires hotter than usual. If there were no fuse in the circuit, the wires would become so hot that they might start a fire. But if there is a fuse in the circuit, the wire in the fuse melts.

If the fuse in your home melts, you can be sure that there is a reason for it. If there is a short circuit, the wires should be insulated, or covered with cloth or some other material that will not conduct electricity, before the fuse is replaced. If a cord or some electrical appliance caused the fuse to melt, the damaged cord or appliance should be repaired before it is used again.

After the current passes through the switch and the fuse in the switch box, it flows into a meter. This meter measures the amount of electricity used in the home.

Wires lead from the meter box through the side walls and across the ceiling. The lights, switches, floor plugs, and wall plugs are wired from these two wires.

The electric current flows through one of the main wires from the meter into the light sockets, switches, and floor and wall plugs. Then the electric current flows back through the second main wire into the meter, the switch box, and one of the large wires in the cable that connects your home with the city power line.

When the electricity that left your home enters the city power line, it travels back through the substations and into the generator again. Here the electrons are pushed once more by the lines of force around the poles of the magnet. So once more electrons move through the power lines that supply electricity to the people living near them.

Day after day, year after year, electrons are moving, changing our nights into days and furnishing the power we need to run our machinery.

THINGS TO THINK ABOUT

1. Why is a dry cell marked with a certain date? After the date marked on the dry cell has passed, people are not allowed to sell it. Why is this a good idea? For what purposes do men use dry cells?

2. Where are some of the largest generators in the United States located? Why are they built in those places?

3. Where does the generator that furnishes your home with electricity get its power?

4. Electricity is used to run motors. How many motors in your home are driven by electricity? At school?

5. How many different places can you think of in which electric lamps are used to change night into day?

6. Imagine that all the generators in the world were shut off for a week. How would man have to change his way of living?

7. Why is a fuse like a switch?

8. Why is it dangerous to use anything except a new fuse when the old one burns out?

9. What are some of the things you should know when you change a fuse?

10. In some homes, a cut-out box is used in place of a fuse box. If there is too much electricity flowing through the wires a switch breaks the circuit. When the trouble has been located the switch may be closed again.

THINGS TO DO

1. Make a water wheel.

2. Examine a flashlight. Explain how it works.

3. Take an electric-light socket to school and tell how it operates.

4. Cut open a dry cell and find the principal parts.

5. Make an electromagnet. Find out how far away it will attract pieces of iron or steel. What does this prove?

6. Tell how the electricity used in your home is generated.

XII

Methods of Communication

HOW ANCIENT PEOPLE SENT MESSAGES

MESSAGES BY DOTS AND DASHES

MESSAGES BY TELEPHONE

MESSAGES BY RADIO

MESSAGES BY TELEVISION

WHEN human beings first appeared on the earth, they did not have a language which they could use to talk with one another. They had to discover a way to let their families and their friends know what they were thinking.

At first grunts and signs were probably used. People did not need to communicate with one another very often in those days. Each ancient family got the things it needed without the help of other people.

But as the centuries passed, it was learned that there were many different ways in which one could earn a living. One could earn a living by raising animals, by raising food crops, or by trading, making pottery, or working with metals. When people began to buy and sell from one another, a spoken language developed.

Many hundreds of years passed before men became dissatisfied with a spoken language as the only means of communication. Then people began to feel the need for a better way to send messages from one village to another. They did not like the idea of sending an important message by a friend or messenger. As a result a written language was developed.

Less than two hundreds years ago people living in the different countries of the world had to depend upon mounted messengers or travelers to carry their letters. When the colonists living in the United States and Canada began to move farther westward, they wanted a better way to send news. Letters sent by mounted messengers, stagecoaches, and ships took many weeks to reach the right persons. There was a need for a more rapid way to send messages.

About one hundred years ago it took a message many days to cross the ocean. Today a message can be sent across the ocean in a few seconds. In this story you will learn how methods of communication have changed.


NBC
A
B

C

How Ancient People Sent Messages

MESSAGES BY SIGNS AND PICTURE WRITING

You may have wondered how people who lived many thousands of years ago talked with one another. It is likely that the men of the Stone Age used signs something like those which the American Indians used.

There were many tribes of American Indians, and each tribe had a different language. When it was necessary for the American Indians to send news from one tribe to another, they used signs. The breaking of a stick was the Indian sign for strength. When an Indian drew his finger across his forehead, he meant "white man who wears cap." The American Indians scratched their chests when they wanted to express something about fire.

The men of the Stone Age also learned to draw pictures on the walls of their caves. Picture writing was the first written language used.

At first pictures were drawn of the animals that were hunted; but as the centuries passed, ancient men learned to draw pictures of themselves, of the tools they used, and of the different kinds of things they did.

These pictures that were drawn on the walls of the cave homes are very important, because they tell us how men lived thousands and thousands of years ago.

MESSAGES BY DRUMS AND FIRES

Men also used drums to send messages. Before men could make a drum, they had to discover that some things make louder sounds than others.

The first drum was probably a hollow log. A hollow log makes a better drum than a solid log because it makes a louder sound. This kind of drum may have been used to call the hunters together before they set off on the hunt, or it may have been used as a danger signal.

As the centuries passed, big drums, middle-sized drums, and little drums were made. These drums were used for many different events. Big drums were used to call the warriors together. Little drums and middle-sized drums made music for the people while they danced together. The beat of a drum told the ancient people many things. Good news,

American Indians using a sign language

bad news, and the call to war were only a few of the things that could be expressed by different drum beats.

The African natives are very skillful in sending and receiving messages by drums. If you were to travel through some parts of Africa today, you would hear the beat of the African drums, or tom-toms. The beat of the tom-tom tells the natives many things about you long before you arrive in their village.

It is very easy to imagine how signal fires happened to be used to send messages. Even in ancient days there were forest fires. Forest fires can be seen for great distances. Perhaps some cave man looked out of his cave door at night and saw the flickering of a forest fire several miles away. This may have made him think about using fires for signals.

Ancient people may also have used signal fires and smoke signals much as the American Indians did. The American Indians, even after they had tribal languages, used signal fires and smoke signals for sending messages to other tribes. The Indians built their fires on hilltops. One fire meant "camp is here." Two fires meant "I am lost." Three fires meant good news, and four fires called the Indians to the council fire.

The American Indians often used smoke signals to send messages to hunting parties. Before the hunting party left camp, they decided on the time to send their signals.

At the time agreed upon the Indians in camp would quietly hurry out of the woods and crawl to the top of the nearest hill. Here they awaited news from the hunting party.

Miles away the signaling party would also seek the highest hill. Upon the peak of this hill they built a large fire. As soon as the fire began to burn brightly, they smothered it with wet wood and leaves. Then two Indians


Galloway

The drum is used in Africa to convey messages for hundreds of miles. Negroes do much of their telegraphing in this manner at night

stretched a blanket across the fire and waited for the blanket to fill with smoke. As the blanket filled with smoke, they raised the blanket and beat the column of smoke in the direction of the waiting party at camp.

Once, twice, and three times, the watching Indians might see the smoke arise into the air. When the Indians from the camp received the smoke signals, they hurried quietly through the dark forest to their homes.

MESSAGES BY RUNNERS

Drums, signal fires, and smoke signals could not be used to send messages to people who lived very far away. So at first ancient people had to send runners or messengers.

The rulers of ancient countries trained young men to carry their messages. These young men had to memorize the messages. If they were to take a very long message to another city, they carried a stick, and for each thing they had to remember they cut a notch on their stick.

As the centuries passed, written language was used. About four thousand years ago Hammurabi, king of Babylon, hired teachers to write his messages on clay tablets. If these messages were to be sent any great distance, they were relayed from one runner to another until the message reached the person to whom it was sent.

MESSAGES BY MEN ON HORSEBACK

About two thousand years ago Cyrus, king of Persia, started the first mounted postal, or letter, service. For many centuries messengers of the king galloped across the Persian plains with letters. This postal route was also organized in relays.

Whenever King Cyrus wanted to send a message, he called his scribe. The king told the scribe what he wished to have written. The scribe wrote the letter and gave it to a postal messenger. The postal courier mounted his horse and galloped to the first relay station. Here a second messenger took the message, jumped on a fresh horse and galloped to the next relay station. The messengers galloped from one relay station to another until finally the letter reached the ruler or nobleman to whom it was written.

Less than two hundred years ago people living in North America were still using mounted messengers. Only rich people or persons holding a public office could afford to send messages. Most people had no safe way to send word to friends or relatives living in distant colonies.

When the colonists living in the North American colonies wanted to send a very important letter to a friend or relative, they would stop travelers and ask them where they were going. If the traveler passed near the home of their friend or relative, they asked him to carry their letter.

Sometimes the American colonists wrote as many as four letters to the same person, hoping that one of the letters might reach the person addressed. At that time there were very few roads in America and no bridges. Whenever the traveler came to a stream, he urged his unwilling horse to cross it. At times the water was so deep that the horse had to swim. When this happened, the letters in the traveler's leather saddlebag got so smeared that they could not be read. Then of course there were also times when the rider never reached the end of his journey.

In 1692 the first postal route was organized in the North American colonies. Mail was carried once each month between Philadelphia and New York City. In 1789 post offices

were opened in upper Canada. For a time the postal messenger made the trip once a year. He traveled partly on snowshoes in winter and by boat when the water was free from ice.

As the colonists moved farther westward, it was even more difficult for them to send or receive messages. There were two ways to send a letter from the state of New York to California. The letter might travel by ship around Cape Horn. Or it might travel by ship to the Isthmus of Panama; then by riders to the Pacific coast; and by ship to the coast of California. It took a letter many months to reach California by either route.

In 1860 there were two routes by water and two routes by land between the eastern and western coasts

When trains began making the run from New York to Missouri, a letter could reach California in five or six weeks. Stagecoaches met the trains at the end of the tracks and carried the mail the rest of the way.

But mail service was still too slow for people who lived so far apart. So in 1860 some Americans organized the pony express. The pony express made the two-thousand-mile trip from St. Joseph, Missouri, to Sacramento, California, in eight or nine days.

The exciting adventures of the pony-express riders ended only sixteen months after they made their first journey. A way was discovered to send messages with a speed almost as fast as that of light. The telegraph had been invented. News could now be sent from coast to coast in a few minutes and the messages could be sent for a few cents. The pony-express riders had charged five dollars for every letter they carried.

Messages by Dots and Dashes

MAN INVENTS THE TELEGRAPH

It took much longer than a day, a month, or even a year to invent the telegraph. For many years men had been making discoveries about electricity. Each of these men helped to invent the telegraph.

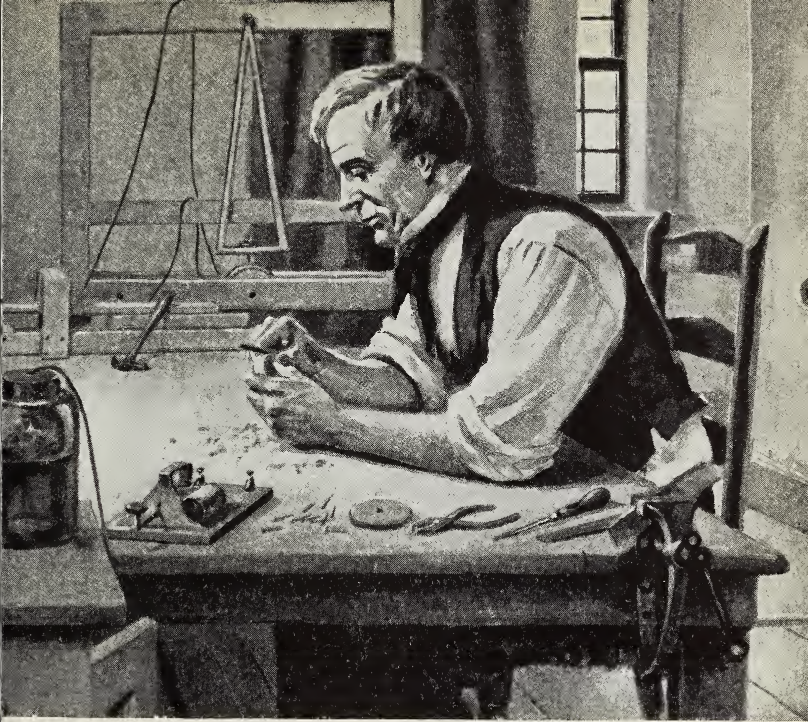
Many people had heard the sharp click of an electromagnet as it attracted an iron bar and then let it go. Some of these people had even thought that an electromagnet might be used to send messages short distances. Some had tried it and found that it could be done.

Samuel F. B. Morse was the first man to invent a practical telegraph instrument that could be used to send messages long distances.

Morse became interested in electromagnets when he was on a boat returning from Paris. While on board ship he met a Dr. Jackson who had seen several new inventions in Paris, among which was an electromagnet. Dr. Jackson had brought a small electromagnet back with him.

A •—	J —•—•	S •••
B —•••	K —•—	T —
C •• •	L ——	U ••—
D —••	M ——	V •••—
E •	N —•	W •——
F •—•	O • •	X •—••
G ——•	P •••••	Y •• ••
H ••••	Q ••—•	Z ••• •
I ••	R • ••	

The Morse code



Morse working on his telegraph instrument

Morse was in a group of people whom Dr. Jackson told about the new inventions, especially the electromagnet. Someone asked Dr. Jackson how long it took electricity to travel through the great lengths of wire wrapped around the piece of iron. Dr. Jackson said that the electricity traveled through it almost instantly. If this were true, Morse was sure that an electromagnet could be used to send messages almost instantly, too.

Morse began to work at once on his new idea. When he left the ship, he had plans worked out by which he could

send messages by dots and dashes. He had invented the Morse code.

For several years Morse earned his living by painting. In every spare moment, however, he worked on his new idea. He had many difficulties to overcome before his instrument was built. He could not buy an electromagnet; so he had to go to a blacksmith and have him bend a piece of iron into the shape of a horseshoe. He could not buy insulated wire. He had to buy wire and thread, and wind the thread around the wire by hand. These were only a few of the difficulties he had while he was building his first crude instrument. This required years of work.

During this time a man by the name of Alfred Vail became interested in Morse's plans and offered to help him. Vail not only worked side by side with Morse, but he also gave him money. These two men in six years built a new instrument that would work much better than the first one. Even after the instrument was built, there were many things to do. Morse had to secure, or get, a patent. Then he had to prove to the public that this invention would do what he said it would do.

In 1844 the first telegraph line, between Washington, D. C., and Baltimore, was completed, and the first message by dots and dashes was sent through the wires. The sending of that message was a wonderful event, even though it is not far from Washington, D. C., to Baltimore.

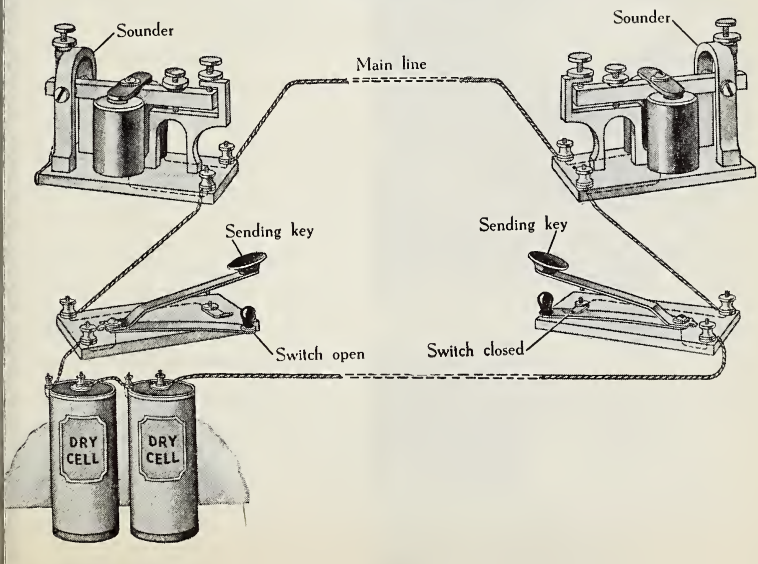
HOW THE TELEGRAPH WORKS

The Morse instrument consists of a sending key and a sounder mounted on a board or some surface that will not conduct electricity. The sending key is a switch that opens

and closes the circuit. A spring which is attached from the key to the board on which it is mounted causes the key to spring up when it is released. This leaves a small space between the key and the wire that connects it to the sounder in a distant station. Electricity flows through the wire below the key only when the key touches it. The sounder consists of two pieces of soft iron with coils of wire wrapped around them. The coils of wire are fastened together so that the electric current can flow from one coil of wire into the other. These coils of wire are fastened to the surface on which they are mounted. A soft-iron bar is connected by a spring to a frame which extends above the coils of wire.

When the sending key is pushed down, the circuit is closed and electricity flows through the coils of wire in the sounder and changes the pieces of soft iron inside the coils into electromagnets. The electromagnets attract the soft-iron bar. When

A two-way telegraph circuit



the soft-iron bar strikes against a piece of metal near the electromagnets, it makes a loud click.

When the sending key springs up, the circuit is again open. The soft pieces of iron in the sounder are now no longer magnets; so they let go of the iron bar. The spring which is fastened from the iron bar to the frame causes the bar to move away from the electromagnets. Two clicks close together mean a dot; two clicks farther apart mean a dash.

A simple telegraph circuit consists of two telegraph instruments, an electric current, and copper wire. The copper wire connects the sending key in one instrument with the sounder in the second instrument. The electric current is always present in the circuit.

Most electric circuits need two wires to complete them; but a telegraph circuit needs only one, because the ground can be used in place of the second wire.

At first only one message at a time was sent over a wire. A few years later someone learned that a wire could carry at the same instant one message in each direction. Today operators can send scores of messages over a wire at the same time. Think of the many thousands of tons of metal that can be used for other things as a result of these discoveries.

Receiving a telegraph message on a telegraph typewriter
Western Union Telegraph Company

Methods of sending telegraph messages are also changing. Many telegraph stations are using telegraph typewriters in place of Morse instruments.

A telegraph typewriter makes it possible for an operator to type a telegram on a machine that has a code keyboard. Almost instantly the receiving telegraph typewriter in a distant station prints the telegram on a paper tape. The tape is then gummed to a telegraph blank for delivery. Telegraph typewriters are used for sending cablegrams under the ocean as well as on land lines.

As a message travels over a wire, the current that carries it becomes weaker and weaker. Telegraph messages that are sent great distances must pass through relay stations. In the relay stations the messages are changed to another circuit that has a stronger current of electricity. By means of relay stations telegraph messages can be sent over thousands of miles of wire to far distant places.

MEN LEARN TO SEND CABLEGRAMS ACROSS THE OCEAN

Morse had to solve many problems when he decided to build a telegraph line between Washington, D. C., and Baltimore. But the men who decided to lay a cable between North America and Europe had to solve even greater problems.

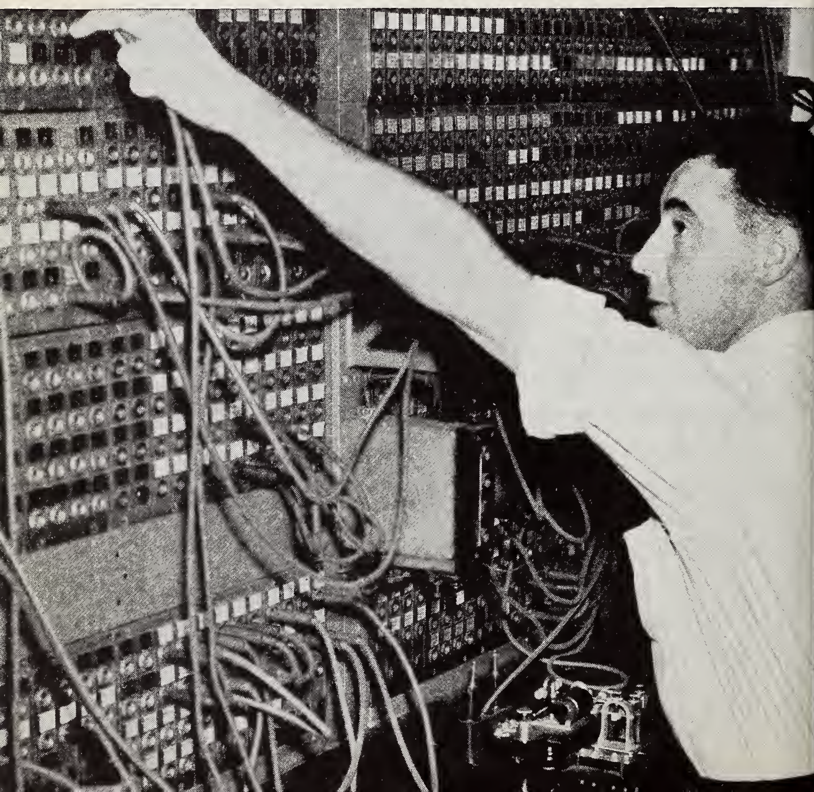
After Morse proved that he could send messages by telegraph, men began to think of a way in which they could lay a cable across the Atlantic Ocean. These are some of the problems they had to solve:

Since salt water is a good conductor of electricity, the cable had to be insulated to keep out the water. The insulation had to be elastic, or springy, so that the cable would not break

under its own weight and the strain of the many thousands of pounds of water on it.

When the electric current reached the other end of the cable, it was too weak to pull down the iron bar on a sounder. A new kind of telegraph instrument had to be invented. Lord Kelvin, an Englishman, invented a receiving set that operates on a very weak electric current. The weak electric current moves a small pen up and down on a strip of paper. The cablegram operator easily reads these jagged lines.

Wire chief setting up a circuit



It took men more than thirty years to learn how to build a telegraph circuit between New York and England. Today twenty-one cables lie on the bottom of the ocean, connecting North America with Europe. Cables lying on the bottom of the South Atlantic Ocean carry messages from the United States, Canada, Europe, and Africa to South America. England can get in touch with any of her colonies in just a few moments by the cables that unite them.

More than two hundred thousand miles of cable make it possible for people in all parts of the world to send messages to one another with a speed almost as fast as that of light.

THINGS TO THINK ABOUT

1. In 1810 mail was sent twice a month by messenger from Montreal, Quebec, to Kingston, New York.

2. In 1820 it cost 92 cents to send a letter from London to Quebec. During this time it cost about eightpence, or sixteen cents.

3. What are some of the things that delay the receiving of a telegram?

4. Why would telephoning a message from the telegraph station take as long as sending the message by telegraph?

5. What is it that carries the message over a telegraph wire?

6. How do newspapers secure their news from distant places?

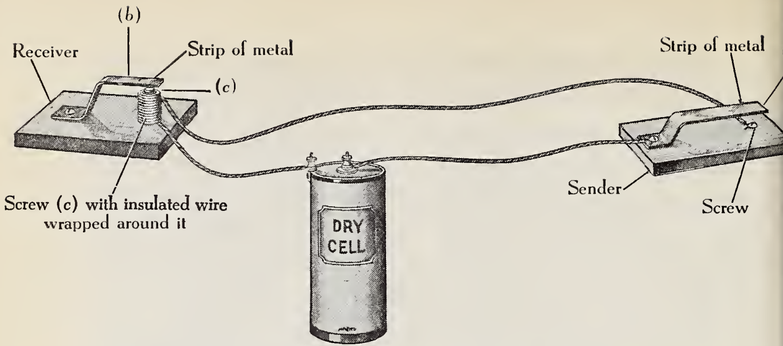
7. Why is there a telegraph operator in every railroad station?

THINGS TO DO

1. Read about the life of Samuel F. B. Morse.

2. Read about the laying of the first Atlantic cable.

3. You can make a very simple sending and receiving set. Secure a thin strip of iron. You may use the iron strips found on fruit crates, or a steel spring. Strips from a toy mechanical set may be used. Put a short screw in a small block of wood. To this screw attach a piece of insulated bell wire. The insulation should



A sending and receiving telegraph set that is very easy to make

be scraped from the end of the wire so that the bare wire touches the screw. Remember to do this whenever you connect a wire. Attach the other end of the wire to a dry cell. Nail or screw the end of a short strip of iron (*a*) to the wooden block, as shown. The strip should be long enough to touch a screw which you will have to drive into the other end of the block. Bend the strip so that it does not touch this screw except when you press down on the strip. This makes the sender.

On another block nail a longer strip (*b*) and bend it. Under the end of this strip put a long screw (*c*). Wind an insulated wire around this screw. Make the turns of wire very close together. Connect one end of this wire to the dry cell and the other end to the screw which is under but does not touch strip (*a*). Now press on the sender (*a*). If everything is all right, (*c*) becomes an electromagnet and pulls down the strip (*b*). Take your finger off the sender, and the receiving strip (*b*) should fly back into place. Why? If you bend a nail so that (*b*) touches it when it is released by the electromagnet it will make another click. Can you cause the receiving strip to sound out dots and dashes?

4. Compare means of communication between New York City and California, Ottawa and Victoria, before and after the invention of the telegraph.

Messages by Telephone

MAN INVENTS THE TELEPHONE

One invention often makes another invention possible. About forty years after the first message was sent by telegraph, the telephone was invented. Alexander Graham Bell became interested in a telegraph instrument that he saw while he was in Scotland. He wanted to know more about it.

As a professor of speech Bell had learned many things about sound. He knew that sound is made by any object that moves back and forth even though we cannot always hear that sound. When he pressed down upon a piano key, he saw the string move back and forth, or vibrate. In his

Alexander Graham Bell proves to a group of his friends that a telephone is practical

From *Leslie's Illustrated Newspaper*, 1877

voice-training work he had noticed that whenever he made a certain sound the piano string that made the same sound answered back. He knew that a string would vibrate. This made him wonder if it would be possible to send the vibrations of the human voice over a wire.

He began picturing to himself how it might be done. He imagined that he could build an instrument that had a flat, circular plate of iron which would vibrate just as a person's voice vibrates. He thought that this plate would have to be connected by a wire to another flat, circular iron plate at the opposite end of the wire. He believed that the first iron plate would cause electrical vibrations which would be carried by the current in the wire to the second plate. He thought that the electrical vibrations would make the second plate vibrate just as the person's voice made the first iron plate vibrate. Then he imagined that the person listening to the vibrating iron plate would hear the speaking person's voice.

Although Bell knew how the "singing telegraph," or telephone, should work, he found it quite a different matter to build one. He worked hard and long, with little success.

Later Thomas A. Watson offered to help him; and the two men toiled for many months in an attic workroom. Both men were poor; but even in months of need the two inventors continued to work on their instrument that should talk. They made many devices and many attempts. Time after time their experiments failed to work. But they believed in their idea, and so they kept on working.

Quite by accident one day they discovered the way to make their instrument talk. While they were experimenting, Watson picked a wire that had stuck. It caused a sound in the instrument upon which Bell was working. The two men immediately began work on a new device.

Wilson

Experimenting with two-way telephone circuit

In 1885 they succeeded in making the sending part of a telephone, or the transmitter, and a receiver out of a clock spring. One day as they were working, Bell said into his instrument, "Mr. Watson, come here, I want you." Watson heard him over his instrument and rushed into Bell's room. This was the beginning. It took ten more months of hard work before they completed an instrument that could be used for any distance.

Bell called his invention a telephone. The Greek word for "far" is *tele*, and the Greek word for "sound" is *phonos*. What better name could he have given his instrument than telephone, far sound? At that time Bell did not realize

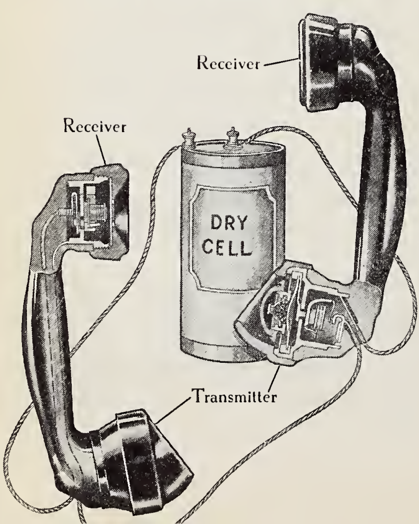
through what great distances this invention would carry the sound of the human voice. Today almost all parts of the world are connected by telephone circuits.

HOW THE TELEPHONE WORKS

Do you have a desk telephone in school that you can take apart? Unscrew the top part of the receiver and find the thin, circular sheet of iron, which is called the diaphragm. If you do not have a receiver, look at the picture on page 375 and see if you can find this piece. The diaphragm is the part that sends sound waves into the air. As you take off the diaphragm, do you notice that it is pulled by something underneath? A permanent magnet holds the diaphragm in place. There are also an electromagnet and two wires leading out from the electromagnet.

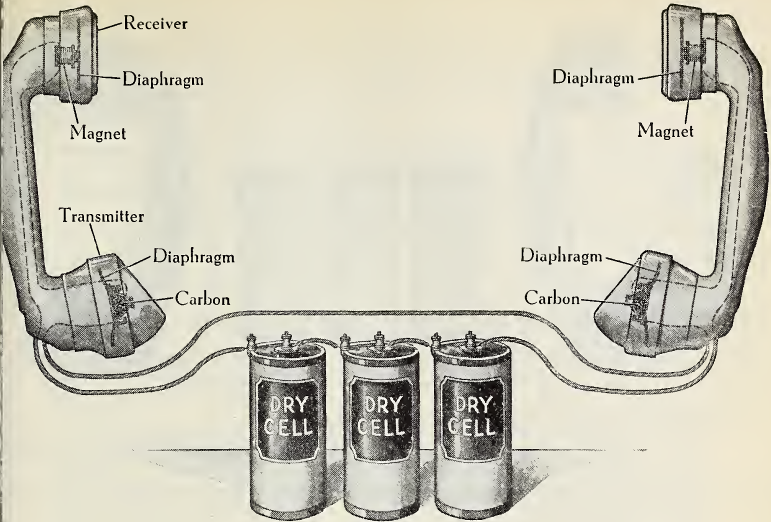
You will need two desk phones to do the following experiments.

A one-way telephone circuit



Connect the two desk-telephone receivers and a dry cell as they are connected in the illustration. Have another child talk into one receiver as you listen at the other. Can you hear him? You can answer back, and he can hear you. It was with two receivers that Bell and Watson first talked. Later Bell made the transmitter.

The transmitter is the part of the telephone into

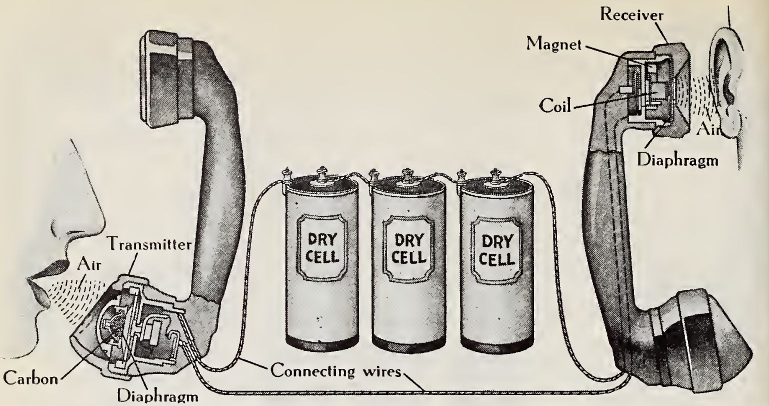


A two-way telephone circuit

which we talk. Notice that it also has a diaphragm. Back of the diaphragm is a little box with tiny pieces of carbon in it. There are two wires leading out from the transmitter. Connect one of the wires on the receiver of one desk phone to one of the wires on the transmitter of the second desk phone. Be sure that the two bare wires are connected. Connect the other two wires to the dry cell. This allows an electric current to pass through the transmitter into the receiver.

Have your friend talk into the transmitter. Can you hear what your friend says? You have set up a tiny telephone system. With this setup you cannot answer. If you have two transmitters and two receivers, try to set them up so that you can talk to each other.

Should you like to know how the words came to you from your friend? The vibrations of your friend's voice make the air in front of the transmitter vibrate just as the voice



A telephone message travels first by air, then by electrical waves, and finally by air again

vibrates. The vibrations in the air made by your friend's voice strike the diaphragm of the transmitter. As they strike the transmitter, they bend the diaphragm just a little. The diaphragm presses the tiny pieces of carbon in the metal box closer together.

There are no wires going through the carbon. The electricity must pass through the tiny pieces of carbon. These little pieces of carbon must be touching one another before the electrons can move about. If many pieces are touching, many electrons move, and the current of electricity is strong. If there are only a few pieces of carbon touching one another, just a few electrons move, and the current of electricity is weak.

Let us see what is happening at the receiver. The current coming over the wires to the receiver becomes stronger as we speak into the transmitter. This makes the electromagnet in the receiver stronger, and it pulls the diaphragm closer to it. When only a few electrons move about in the wire the

current is weaker. When the electromagnet is weak, it does not pull the diaphragm so hard; so the diaphragm springs away from the electromagnet.

The backward and forward movement of the diaphragm causes the air around the receiver to vibrate. These vibrations, or sound waves, are like the ones that struck the transmitter. The sound waves strike the eardrum. These vibrations strike the small bones in the ear. The nerves in the ear carry the message to the brain. The brain has learned to understand the meaning of certain vibrations. It tells us what the vibrations mean.

We do not realize that every time we hear a sound, which is really nothing more than a number of vibrations, our brain must change these vibrations into a meaning. The nerves in our ear carry the message to our brains so fast that we never realize what is happening at all.

Messages are carried all over the world by this wonderful instrument, the telephone. Highways of wire stretch out over the world for many thousands of miles. We have learned to depend upon these highways for many different things.

THINGS TO THINK ABOUT

1. You have probably heard that the Indians and early settlers used to put their ears near the earth to listen for the approach of an enemy. Why did they do this?

2. What are some of the ways we use sound in communication?

3. What are some of the ways we use light in communication?

4. How have the telegraph and telephone helped to develop the United States and Canada?

5. Why did men have to know about electromagnets before they could invent the telephone and the telegraph?

THINGS TO DO

1. Take two very small tin cans and punch a tiny hole through the bottom of each. Pull the end of a long string through the hole of one can from the outside. Tie a big knot in the string on the inside of the can so that the string cannot slip out. Stretch the string the length of the room and put the other end of it through the other can, just as you did in the first one. Have a friend talk softly through one can, and you listen through the other. Be sure that the string is stretched tight. By using this set you may carry on a conversation. You can do this same thing at home. Stretch a string from your room to the room of a friend next door. Each one has a can. You might use a wire instead of a string. This can be your private telephone.

How can you hear over this small set? Do you feel any vibrations in the cans? Why is it better to use a wire than a string? Tell how the vibrations go from your mouth to the friend's ear. Sound waves travel through the wires in the play telephone set. How far do sound waves travel in a real telephone?

2. Give a show where you make a dummy, or doll, talk. One child holds a conversation with the doll on the stage. Another child, behind a screen, makes the doll talk. He does this with a long rubber or metal tube that goes from behind the screen at the back of the stage up to the doll's mouth. The tube should not be seen. The child behind the screen talks through the tube, and it sounds as if the doll were talking.

Messages by Radio

MAN INVENTS THE RADIO

The invention of the telegraph and the laying of the first telegraph cable across the Atlantic Ocean were great events in the lives of people who had depended upon ships and horses to carry their messages. It was also a great event when Alexander Graham Bell and Thomas Watson invented the telephone. These two men made it possible for people to remove the receiver from the telephone in their homes and talk to people who live many miles away.

The invention of the telegraph and the telephone were great inventions, but they do not seem nearly so great as the invention of the wireless and the radio.

It was a most exciting day when Guglielmo Marconi, an Italian, received the first wireless message over the Atlantic Ocean from Cornwall, England. It happened in the year 1901. Marconi was sitting in a small room in a signal station in St. John's, Newfoundland. He had clamped a set of earphones on his ears and was leaning over his wireless receiving set. Suddenly he heard something, and he clamped the phones more tightly against his ear. He listened to the first wireless message, which consisted of three whistling sounds.

Those three whistling sounds meant the same to Marconi that the three dots of the Morse code mean to a telegraph operator. You can imagine the excitement in that little signal station when Marconi told the great news. A message had traveled all the way from Cornwall, England, to St. John's, Newfoundland, through the air. Marconi had succeeded. He had made an instrument that could be used by people who were far from electrical wires.

The wireless is as important to a captain on a ship at sea as the telegraph is to an engineer on a railroad. If anything should happen to the wireless set on a ship, the crew and passengers would have no means of communicating with other people. Think of the lives that have been saved since men invented the wireless! Wireless telegraph sets were used on ships for sending messages to shore or to other ships for many years before the radio, or wireless telephone, was invented.

HOW THE RADIO WORKS

The wireless set used by a ship at sea works very much like a telegraph instrument. The operator pushes a key when he wishes to send a message. A key can be used only to send the dots and dashes of the Morse code. But a radio works differently. When you remove the receiver from a telephone and talk through the transmitter, your voice makes the current of electricity vibrate. A radio, or wireless telephone, works in a similar way.

Imagine that we are in a broadcasting studio listening to a program. Let us follow the electrical, or radio, waves that flow out from the broadcasting station in all directions.

A man is singing before the microphone in the studio. This microphone is plugged into the electric current in the studio. The vibrations of the man's voice make the air in front of the microphone vibrate. The vibrating air strikes the thin metal diaphragm in the microphone. The vibrating diaphragm makes a weak current flowing through the microphone vibrate. The vibrating electric current flows out of the studio into a large broadcasting room. These vibrations of the electric current are called voice waves, because they were made by the vibrations of the man's voice.

In the broadcasting room the electrical voice waves travel through small wires in a vacuum tube, where they are made stronger, or amplified. The amplified voice waves enter another vacuum tube, where they join with very powerful electrical waves. These powerful electrical waves, joined with the voice waves, flow out into the air in all directions. We cannot see the powerful vibrating electrical waves, or radio waves, as they travel through the air. They are speeding along at the rate of 186,000 miles a second. We cannot hear them, because they are vibrating too fast.

The powerful electrical waves are made up of millions and millions of groups of tiny electrons. Groups of electrons, or electrical waves, are of many different lengths. Each broadcasting station is given a certain wave length. When you turn the dial of your radio, you are really making your radio pick up a certain wave length.

The farther the radio waves travel, the less they push. You have learned that when electrons push very hard, the current of electricity is strong. When the electrons do not push so hard, the current is weak. If these waves are strong enough to make the electrons in the aerial vibrate, you will be able to hear the program by turning your dial to the proper number. When you tune in the radio to this station, the electrons that are vibrating in your aerial start the electrons in certain vacuum tubes vibrating. These tubes make the weak radio waves stronger; so they are called amplifying tubes.

These strong electrical waves travel through a tube called the detector. The detector in the radio changes the rapidly vibrating waves into vibrations that are slow enough for you to hear them. After the waves leave the detector they pass through more vacuum tubes that make them stronger.

Then radio waves flow through a coil of wire in the loud speaker. This coil of many windings of fine wire is placed in the magnetic field of a *very strong* electromagnet. The smaller end of a paper cone is fastened to the coil in such a way that the coil and the cone vibrate, or move to and fro, exactly as the radio waves are vibrating. The vibrations of the cone make the air vibrate. When these sound waves, or air vibrations, strike the ear and our mind interprets them, we say we are hearing a radio program.

It has taken a long time to tell about a radio program that travels from the microphone in the studio to the radio in your home. It really takes only a fraction of a second for all this to happen.

When you listen through your radio to a program that is being broadcast from a large auditorium, you are hearing it a fraction of a second before the audience in the back of the auditorium hears it. Radio waves, or electrical waves, travel much faster than sound waves. Electrical waves travel about 186,000 miles a second, while sound waves travel about 11,000 feet in a second. Radio waves travel so rapidly that they can cross the ocean in less than a second.

Because of the great speed with which radio waves travel, news can be carried around the world in a few seconds. The radio has brought all the nations of the world within speaking distance of one another.

THINGS TO THINK ABOUT

1. What travels from the broadcasting station to your radio?

2. In what ways is the radio more useful than the telephone and the telegraph?

3. In what ways are the telephone and telegraph more useful than the radio?

THINGS TO DO

1. Visit a radio broadcasting station.

2. Find out what a patent is. Why do people secure patents?

3. Examine an old vacuum tube. You will find several things in it that will interest you. The wires are made of tungsten. Tungsten is a steel-gray element that can be heated to a high temperature for many hours without melting, as iron or copper would. It can also be heated and cooled many times before it will become brittle and break. For what other purpose is tungsten used?

4. There are 5280 feet in a mile. If you could shout loud enough to be heard 3000 miles away, how long would it take the sound waves of your voice to travel so far?

Galloway

Broadcasting a television program

Messages by Television

MAN SENDS PICTURES BY RADIO

About twenty-six years after Marconi received the first wireless message, a group of people in New York City saw the first radio pictures.

The instruments that are used to send pictures through the air are like the sending and receiving sets in a radio. In fact, the instruments are so much alike that the pictures are often called radio pictures.

These instruments have been given a name that describes what they do. They are usually called television sending and receiving sets. *Tele* means "far" and *vision* means "sight." By means of television instruments we can send photographs, pictures of important events, and copies of letters to all parts of the world in a few seconds. Television instruments make it possible for us to see things that are happening in far distant places.

HOW TELEVISION INSTRUMENTS WORK

The television sending instrument has a photoelectric cell, and a scanning disk. The television receiving instrument has a neon bulb, a scanning disk, and a screen.

The photoelectric cell in the television sending instrument is really nothing more than a glass bulb from which the air has been removed. The glass bulb is coated on the inside with the element potassium. Potassium is very sensitive to light. In the center of the glass bulb is a small loop of nickel wire.

When the photoelectric cell is in the dark, nothing happens. But when the cell is in the light, the electrons in the

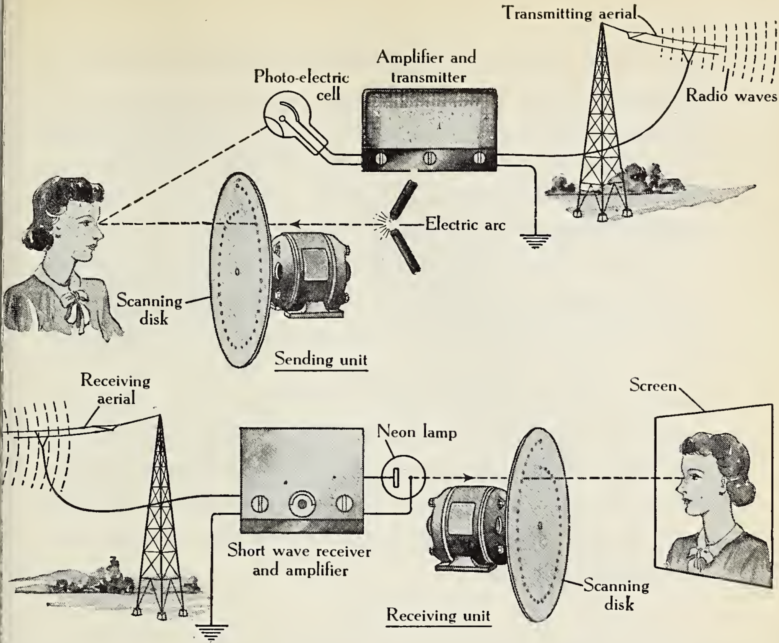
light waves strike against the outside of the bulb. As the electrons strike, they knock off some of the electrons that are clinging on the inside of the bulb. The electrons that have been jarred loose are attracted to the nickel loop of wire in the center of the bulb. As these electrons push against the nickel wire, they set some of the electrons in the wire in motion.

When the light waves striking against the photoelectric cell are weak, a weak current of electricity flows through the nickel loop of wire. When the light waves are strong, a stronger current of electricity flows through the nickel loop of wire. The photoelectric cell is like the diaphragm in the microphone. The cell makes electrical vibrations. These electrical vibrations join with a powerful electric current that carries them to the receiving station.

Let us find out what happens to a picture from the time it is taken by the photoelectric cell until it is seen at the receiving station. It is really very much like having your picture taken.

The person whose picture is to be taken looks through a lens into the hole of the scanning disk. The scanning disk has a number of holes bored near the edge. This disk is connected to an electric motor that whirls around a certain number of times a second. The photoelectric cell is placed near the person's face. A very strong light shines through the hole in the scanning disk upon the person's face. This tiny spot of light on the person's face shines upon the photoelectric cell.

As the scanning disk whirls around, spot after spot of light shines through the disk upon the different parts of the face. If you look at your face in a mirror, you will notice that some places on your face are lighter than others. The



Sending and receiving a picture by television

dark and light places on the face reflect more or less light on the photoelectric cell. This causes weak and strong currents of electricity to flow through the cell. The current from the cell joins powerful electrical waves that travel to the receiving station.

In the receiving station there is a lamp filled with neon gas. An ordinary light bulb will not do, because it does not flash off and on so rapidly as a neon lamp. In front of the neon lamp there is a scanning disk. This disk is whirling around just like the scanning disk in the sending station.

People in the receiving station look through the scanning disk at a screen. As the electrical waves arrive from the send-

ing station, the neon bulb flashes off and on. Sometimes it shines brightly; sometimes it does not shine at all; and at other times it glows very faintly. The neon lamp changes from dark to dim to bright so rapidly that the people do not notice the changes as they flash on the screen. They see all the flashes as one complete picture.

The first television pictures were sent in this way. People still have much to learn about sending and receiving pictures and messages by television. But progress is being made. To-day, in many parts of the world, men are at work experimenting with different parts of television sets. They are making every effort to invent television instruments that will be as useful as the telegraph, the telephone, and the radio. Think how different the world will seem to us when we are able to see the important things that are going on as well as hear them!

A group of children watch a television broadcast

National Broadcasting Company

THINGS TO THINK ABOUT

1. Light from the star Arcturus, which is about forty light-years away, shining on a photoelectric cell closed the circuit that caused the lights at the Chicago World's Fair to flash on.

2. Photoelectric cells are used for many different things. They are sometimes used to turn on the electric lights in office buildings when clouds shut off the sun's light. They are used to open and close doors in railway stations and stores.

3. Can you think of any other ways in which photoelectric cells are used?

THINGS TO DO

Look in the daily newspapers and magazines for pictures that have been sent by television. How do they differ from a picture taken by photography?

XIII

Men Improve Methods of Transportation

TRANSPORTATION BY ANIMALS, WIND, AND WATER

TRAVEL BY STEAM POWER

TRAVEL BY ELECTRICAL POWER

TRAVEL BY GASOLINE AND OIL POWER

HUMAN beings walked from place to place for many centuries before they discovered that there were better ways of traveling.

It was very much easier for men to discover that a log could be used for a boat than it was to learn how to use animals for land travel. Waterways are natural highways. Hence ancient people did most of their traveling by water.

Even after men learned to raise animals and to build wagons, they did most of their traveling by water. At first oars were used to push the boats, and later sails. Sailboats made it possible to travel to far distant lands.

In the seventeenth century men began to migrate, or move, farther and farther away from their homelands. Because people were anxious to get news as well as to trade with one another, they began to look about for better methods of transportation.

In the last three centuries methods of transportation have improved more than they did during many centuries before this period. Not only were more rapid ways to travel by land and water discovered, but machines were invented that could travel through the air.

From very early times men have wanted to fly like the birds. They felt sure that there must be a way to build a machine that could travel through the air. Today we have the airplane. What would ancient men think if they could see the rapid methods of travel by land, water, and air that modern men use?

In this next story you will read about how men have changed their methods of travel.

THE PHOTOGRAPH ON PAGE 391 IS © DOUGLAS FROM GENDREAU.

Transportation by Animals, Wind, and Water

ANCIENT MEN TRAVELED BY LAND AND WATER

It took men a long time to learn how to travel with speed and comfort. Animals may have been domesticated for centuries before it was discovered that they could be used to haul loads. Then many more years may have passed before people realized that animals could carry them as well as their loads. No one really knows how it was discovered that animals could be used to take people from place to place. It may have happened in this way:

Perhaps a man living in the Bronze Age grew tired of walking beside his cart. He may have sat down in the back of the cart and let the animal haul him. This man may have given other men the idea of raising animals to carry them when they wanted to go to places in a hurry. As the years passed, horses were ridden as well as being used for pulling chariots.

A log was probably the first thing used for travel by water. Can you imagine what made people think of using logs for boats? Perhaps one person saw a log with a bird or other animal on it floating down a stream. That may have given him the idea that he too might float on a log. So he may have lain down on top of a log and paddled with his hands and feet. In this way he made the log carry him where he wanted to go. Then other persons began to use logs, too. Perhaps, later, someone discovered that a stick was helpful in moving the log.

Logs did not make very good boats. Round logs turn over

easily in the water. If you have tried to sit on a log in the water, you know how difficult it is to stay on top. Early men often tipped over in the water. To prevent the logs from tipping so easily, men learned to flatten them on top.

After the discovery of fire, and the invention of tools, the inside of log boats was burned and dug out. A person could sit down in these boats and not get wet while traveling. This was a great improvement. The log boat was becoming more and more useful.

Later, logs were fastened together in the form of a raft. Then someone discovered how to fasten logs together so that the raft was rounded on the sides. At last boats were being made that could be used for more distant travel.

Boats became larger and larger, and it took more and more men to row them. When Rome was at the height of her power, she had great boats that were rowed by many slaves. Rowing was slaves' work in many countries. Sometimes there was more than one row of oars on each side of the boat, and the slaves sat on benches one above the other. The old Roman galley was a ship of this type.

After rowing had for many years been the means of driving boats, someone discovered that if a sail were set up, the wind could help to drive a boat. At first only small sails were used, and they were not very successful. Then larger sails were made, and they worked much better. People learned to depend more and more upon the wind to drive their boats. But even so, they continued to use oars as well as sails. It took a long time to learn how to steer sailboats. It was not until the sixteenth century that boats were made without oars. By this time people in Europe were using compasses.

After the inventions of sails and compasses, world travel began. The ships in which these long journeys to faraway

lands were undertaken were much larger than the earlier ships, and they had many more sails.

The boat had developed from one small log into a raft, a galley, and a large sailing vessel. But in spite of these improvements sailing vessels still could not be depended upon. They needed the wind to drive them, and the wind did not always blow in the right direction. Many times ships arrived in port weeks later than they should have arrived.

Often inventions have been made because there was a great need for them. Near the close of the eighteenth century people needed a boat that did not depend upon the wind.

In the United States and Canada there were many rivers which people could use for traveling if they had boats that did not depend upon sails. These people wanted to move to the rich farming lands that lay in the river valleys.

For many years, animals were used to haul canal boats

Travel by Steam Power

MAN INVENTS STEAM-DRIVEN PADDLE-WHEEL BOATS

Robert Fulton was the first man who built a steamboat that could stand the wear and tear of travel.

Even when Fulton was a young boy, he was interested in boats. He and his friend used to go fishing in a flat-bottomed boat. They had rigged a pair of paddle wheels, one on each side of their boat. These paddle wheels were fastened to a rod. They made the paddle wheels whirl around in the water by turning the rod with their hands. As the paddle wheels churned and splashed, they pressed backward against the water, just as a wagon wheel presses backward against the ground. The backward push against the water pushed the boat ahead.

Fulton and his friend found that they could go much faster by using paddle wheels than they could by rowing their boat. Can you not imagine those boys bending over the rod and shouting with laughter as the paddle wheels splashed the water in their faces? That first paddle-wheel boat must have been fun.

In 1807 Fulton launched the *Clermont*, a new type of boat, which depended neither on muscle power nor on wind to move it. This boat also had paddle wheels, like Fulton's earlier boat, but now the paddle wheels were driven by the power of steam.

The *Clermont* made its first voyage between New York and Albany. People gathered along the banks of the Hudson River to see the fun. They were sure that the boat would never go. Smoke poured from the smokestack of the *Cler-*

mont. Its paddle wheels splashed as they turned through the water. The boat began to move. Just as it got well started, it stopped. The people along the shore were more sure than ever that the boat would never make the trip. Once again the boat moved, and this time it steamed up the river, making the journey of one hundred and fifty miles in thirty-two hours.

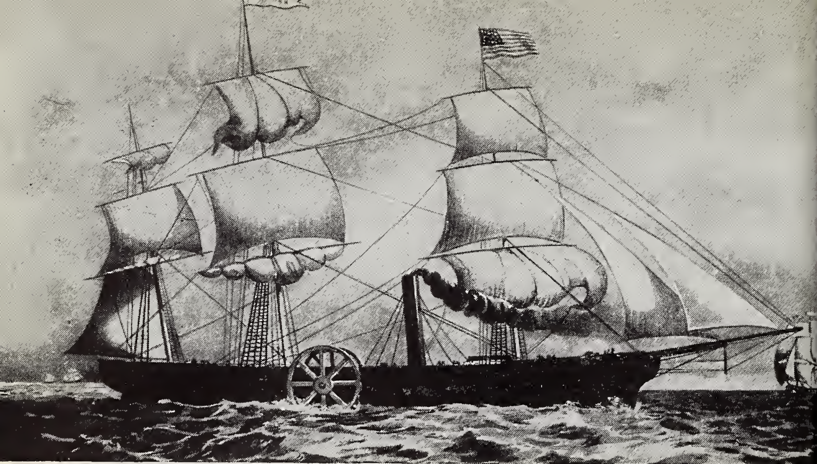
The *Clermont* used pine wood for fuel. As the ship made its way through the water, it left a long trail of smoke and sparks behind it. Sailors in other boats on the river raced to their cabins in fright as the smoking monster passed. Farmers, seeing the cloud of smoke and sparks from the steamer, rushed to their homes shouting, "Here comes Fulton on a sawmill!" After this successful trip, other steamboats were made.

In 1819, about twelve years later, the *Savannah,* the first ocean steamer, left New York for Liverpool. This boat had both sails and paddle wheels. The paddle wheels were built so that they could be hauled on deck when they were not in use. The captain knew that the little steamer was too small to carry enough pine wood and coal to make the crossing by steam power. So whenever the wind blew in the right direction, the captain ordered "Full sail ahead," and the fires in the boilers were allowed to die down. But when the wind changed to an unfavorable direction or the ship sailed in calm seas, the sails were hauled down and the ship steamed straight ahead.

The *Savannah* anchored in Liverpool twenty-nine days and eleven hours after it sailed from New York. Most of the three-thousand-mile journey had been made under sail; but for eighty hours the paddle wheels had pushed the tiny boat straight into head winds and through hours of calm.

© The New York Historical Society. From a painting by H. A. Ogden

Fulton's triumph



The *Savannah* was the first steamship to cross the Atlantic Ocean

After this successful trip other ships depending partly on sails and partly on steam were built. A small Canadian coast steamer, the *Royal William,* was the first vessel to cross the ocean by steam only. It sailed from Pictou, Nova Scotia, August 18, 1833, and arrived in Land's End, England, eighteen days later.

But it was not until the year 1840 that steamships began to make regular trips between England and North America. At this time the Cunard steamship line bought four mail packets to sail regularly from Liverpool to Halifax and Boston.

At first the steamships had masts as well as paddle wheels. Engines were likely to break down, and the waves were likely to crush the paddle wheels. People were becoming discontented with paddle-wheel boats. A paddle-wheel steamer could not go very fast in stormy seas because whenever it rolled from one side to the other, first one wheel and then the other was lifted out of the water.

MEN BUILD STEAMSHIPS WITH SCREW PROPELLERS

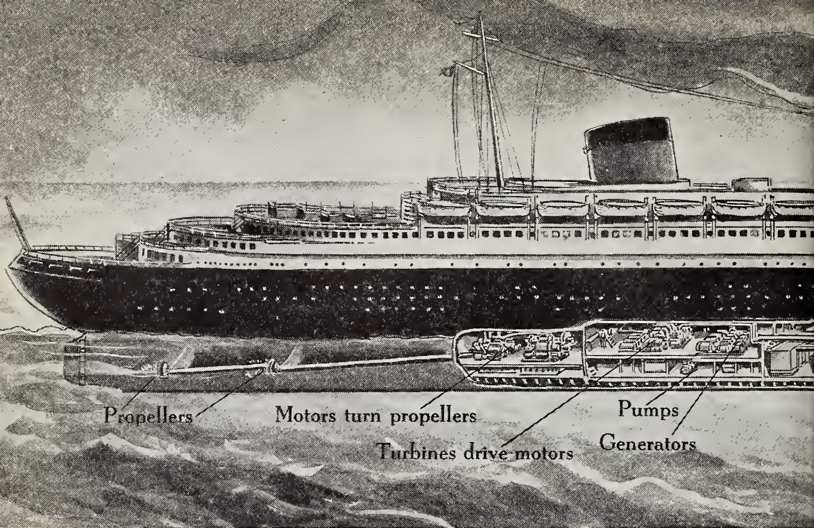
Thomas Jefferson was one of the first men to think of using a water screw to push a boat through the water. The water screw was something like the small metal screw we use to fasten wood together. He suggested that if a screw propeller were placed on a boat, it would push the boat through the water, just as a screw, when turned, works its way through wood.

When screw propellers were first used on ships, seamen said that the propellers would not have enough force to push a big steamship through the water. Besides, they thought it was a very foolish idea to cut a hole in the ship in order to put in a propeller shaft. They said that ships were likely enough to spring a leak without cutting a hole in them.

In 1836 John Ericsson built a steamship with a screw propeller. In order to prove to the people that a screw propeller had more power than a paddle wheel, John Ericsson fastened a paddle-wheel steamship stern to stern with a screw-propelled steamship. Crowds gathered to see the tug of war. The engines of the two steamships were working full force. A few minutes later the steamship with the screw propeller began tugging the paddle-wheel boat upstream.

John Ericsson proved that the screw propeller furnished more power than paddle wheels. Soon after Ericsson made his successful test, shipbuilders began building ships with screw propellers. Today ocean steamships are built with propellers.

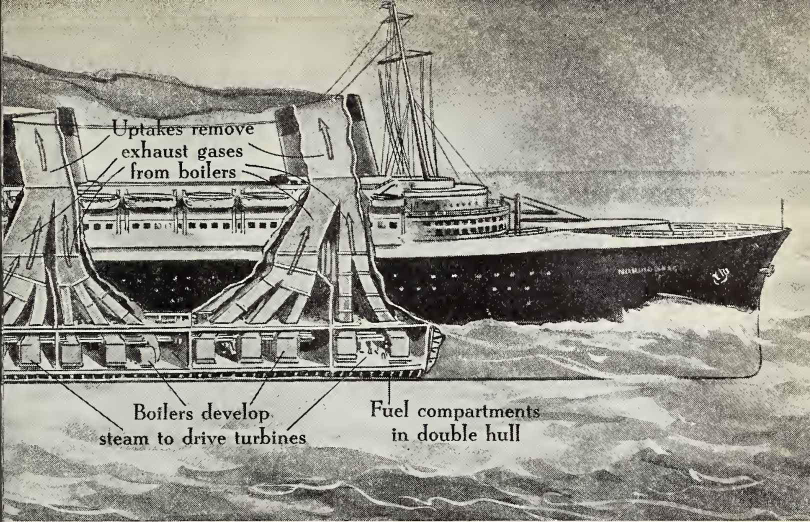
Most steamships have twin screws, and some have as many as three or four. When a ship has a single propeller, the propeller is set in line with the keel. The keel is the lowest part of a ship. It helps to keep the ship balanced. If a



Oil-burning motors propel this

ship has two propellers, they are built one on each side of the keel. A ship with three screws has one in line with the keel and one on each side. If a ship has four propellers, they are set in pairs on each side of the keel.

Think how much has been learned about building steamships since the days when the *Savannah*, fitted out with sails and paddle wheels, made its first trip across the Atlantic. It took the *Savannah* about twenty-nine days to make the crossing. Today a modern steamship makes the same trip in about four days. Not a single passenger would risk the dangers and endure the discomforts on the *Savannah* when it made its first crossing. Today the crew and passengers on a modern steamship can live as comfortably and safely as they can on land. On the most up-to-date liners the passengers can play games, swim, listen to musical concerts, and see motion pictures.



steamship through the water

WHAT MAKES AN OCEAN LINER GO?

Many ocean liners are propelled by steam power. Some liners use coal to change the water in the boilers into steam, and others use oil.

An ocean liner carries large tanks of fresh water to use for making steam power. This water is changed into steam in the boiler. Steampipes carry the steam from the boilers to the large steam turbines. These turbines are built much like water turbines.

As the steam flows out of the end of the steampipe, it strikes against the blades of the steam turbine. The force of the steam striking against the blades of the turbine forces the wheel around.

The turbine is connected to a long shaft that runs through the body of the ship. The propeller is fastened to the end of this shaft. As the turbine whirls, the propeller shaft turns

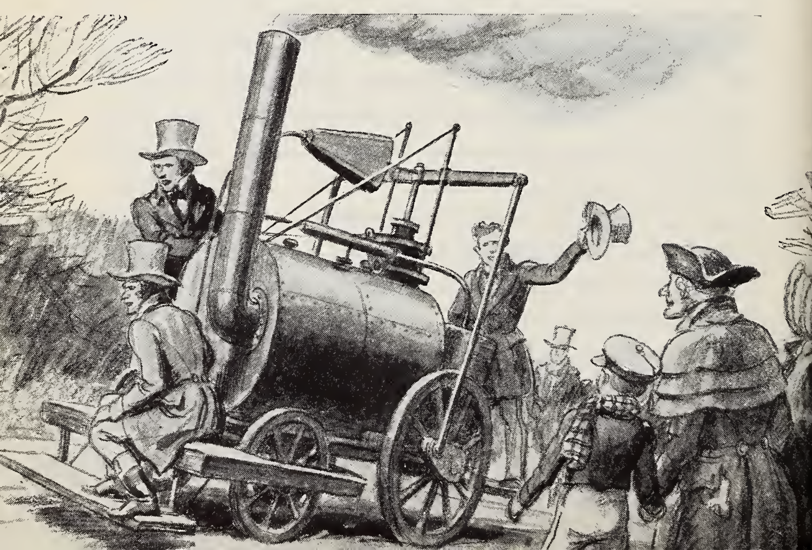
with it. The propeller shaft turns the screw propeller. The blades of the propeller, pushing backward against the water, force the liner ahead.

After the steam has done the work of pushing against the blades of the turbine, it is forced out of the turbine into a cooling cylinder. In this cylinder the steam is changed into liquid. Pumps force the water back into the boilers, where the water is again changed into steam.

MAN INVENTS THE FIRST STEAM LOCOMOTIVES

In 1802 Richard Trevithick built a steam engine to run on country roads. This engine looked very much like a four-wheeled carriage. Friends of Trevithick's persuaded him to drive his steam carriage to London, where he might show it to businessmen.

Trevithick and his steam carriage



While Trevithick was driving his carriage to London, he discovered that the roads were much too rough to use steam-driven carriages on. As he was driving through the streets of London, he had an idea. Coal-miners had been using horses to haul loads on wooden rails for more than a hundred years. If it was easier for horses to haul heavy loads on wooden rails, why would it not be better to use steam carriages on wooden rails?

Trevithick soon set to work to build locomotives to run on rails rather than over country roads. He realized that carriages could never speed over roads until they were greatly improved.

MAN INVENTS STEAM LOCOMOTIVES TO RUN ON RAILS

Richard Trevithick built several engines to run on rails; but they were not very successful. Trevithick had been right in his belief that rails would make it possible for engines to go faster. But even with rails engines could not make any greater speed than a horse, and they used a great deal of steam.

In these early steam engines, after the steam had pushed the piston it escaped through one side of the cylinder into the air. One day a young man, George Stephenson, was watching the steam as it escaped. He noticed that it rushed out with more force than the smoke from the smokestack. He knew that if the fire had more air, it would burn faster. Mr. Stephenson wondered why that steam could not be used to force the smoke out of the stack.

So he built a steam engine that had a pipe leading from the steam cylinder to the smokestack. The force of the steam escaping through the stack forced out the smoke. Air rushed

into the empty space left by the steam and smoke. The fire in the firebox blazed and roared, causing the steam pressure to rise higher than it had ever risen before. Stephenson had discovered a way to make a locomotive do more work.

Shortly after Stephenson had made this steam carriage, railroads were built. In 1829 an English railway company offered a prize to any inventor who could build an engine suitable for hauling freight, mail, and passengers between Liverpool and London. George Stephenson won this prize with his famous engine, the *Rocket*. He made only one important improvement in this engine. Instead of building an ordinary iron boiler, he built a boiler with many small copper tubes in it. The flames from the firebox shot through these tubes and heated the water much faster than it could be heated in the old-style boiler. For this reason the *Rocket* could make more speed than the other engines could.

Stephenson and the *Rocket*

In 1829 the Baltimore and Ohio Railroad Company began building a railroad in the United States. Two years later the *DeWitt Clinton* pulled the first passenger train over the Hudson and Mohawk line between Albany and Schenectady. The engine was only eleven and one half feet long, and the passenger cars looked like stagecoaches.

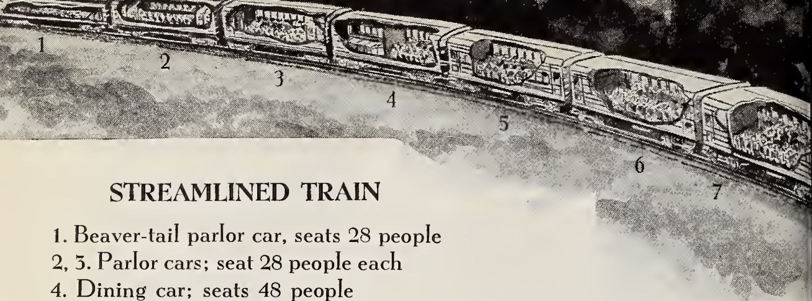
Even after Stephenson had made his improvements on locomotives, there were many more problems to be solved. The railroad companies were not using the same width of track. Since a locomotive and cars from one road could not travel over the track of another road, it was necessary for people to change trains very often.

In some of the towns trains were not permitted to enter the city limits. So it was necessary for the passengers to hire a carriage to take them across the city.

The smokestacks on the locomotives were so tall that the engineers had to stop and remove the smokestacks before they could pass under bridges. How have railroad companies solved this problem?

The tenders behind the engines were so small that they could not carry enough water and wood to move an engine any great distance. Sometimes the engineer and the passengers had to rush down the sides of a riverbank to get enough water to complete the journey. Today engines haul tenders that carry both fuel and water. These tenders are often as long as the engine.

The early locomotives had no steam whistles and no bells. The conductor had to blow a big tin whistle to let the engineer know when the freight was loaded and the passengers were safely in their coaches. Whenever the conductor wanted to send a message to the engineer, he had to shout or wave. Today trains have whistles that work by steam, and bells



STREAMLINED TRAIN

1. Beaver-tail parlor car, seats 28 people
2, 3. Parlor cars; seat 28 people each
4. Dining car; seats 48 people
5, 6, 7, 8. Luxury coaches; seat 56 people each
9. Express
10. Grill; seats 44 people
11. Water tank
12. Tender
13. Coal bin
14. Steam chest
15. Steam cylinder
16. Air pumps
17. Bell
18. Headlight

large enough to be heard several blocks away. When the conductor wants to tell the engineer something, he pulls a rope that runs through the cars and is attached to a small whistle in the engineer's cab. The engineer can tell by the number of pulls on the rope just what the conductor wants him to do.

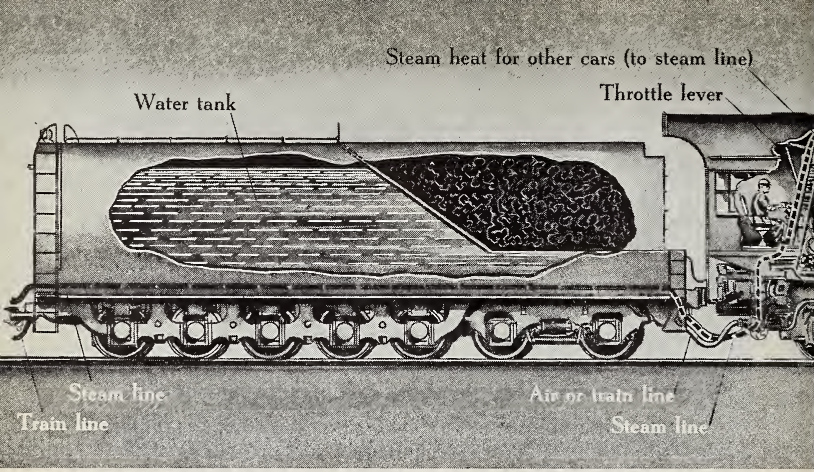
There have been many changes in trains and tracks since the days when the *Rocket* and the *DeWitt Clinton* made their first runs. Today trains whiz along on smooth tracks, carrying the crew and passengers much more comfortably and safely than they used to do.

WHAT MAKES A LOCOMOTIVE GO AND STOP?

The largest parts of a steam engine are the firebox and boiler. These parts of the engine rest on a heavy steel frame which is held by the axles of the wheels. The firebox is in the back part of the engine. Many long tubes go from the

STREAMLINED LOCOMOTIVE

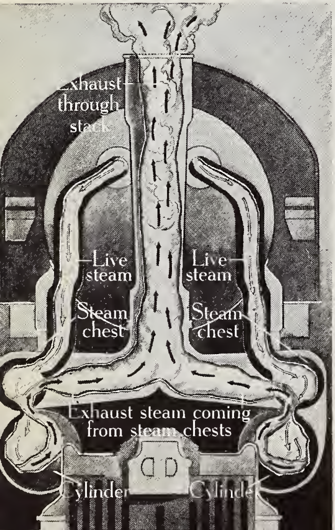
1. Shell, or body, of locomotive
2. Air pump
3. Air-brake cylinder
4. Steam cylinder
5. Air-brake cylinder
6. Boiler flues
7, 8. Compressed-air reservoir
9, 10. Brake cylinders
11. Firebox
12. Steam line to heat train
13. Train line
14, 15. Steam pipes leading to steam cylinder



What makes this

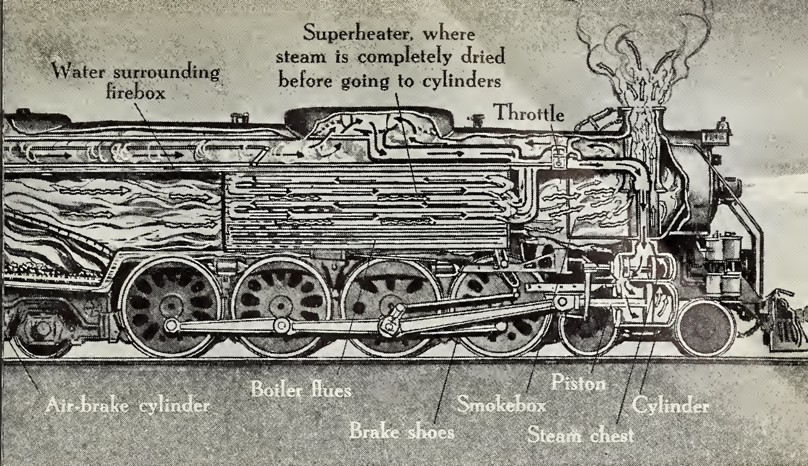
firebox through the boiler to the smokebox. The water in the boiler surrounds these long tubes. As the hot gases rush through the tubes, they heat the tubes and the water around the tubes.

As the water boils, it changes to steam and rises into the steam chest, which is a place where steam is stored. When there is enough steam pressure to move the engine, the engineer pulls the throttle. This lets the steam into the cylinders.



The steam flows from the steam chest into two cylinders, one on each side of the boiler. The steam enters these cylinders, first from one end and then from the other.

The large wheels of the locomotive are called the driving wheels. The driving wheels are coupled to-



locomotive stop and go?

gether by means of long rods. These rods are fastened to steel blocks.

When the steam pushes the pistons in the cylinders, the piston rods pull the steel blocks backward and forward. The steel blocks pull the long rods, and the rods pull the driving wheels. The back-and-forward movement of the long rods makes the wheels go around.

Air brakes stop a train. The engine and each car attached to the engine have air reservoirs and brake cylinders which are connected by an air pipe. An air pump on the engine forces air through the air pipe into the engine and car reservoirs. A brake valve in the engineer's cab also connects with this air pipe. As long as this brake valve is closed a control valve admits air into the reservoirs on the car. When the engineer wants to bring his speeding locomotive to a stop, he operates the brake valve, and air rushes out of the air pipe. This makes the air pressure greater in the engine and car reservoirs than it is in the air pipe. The greater pressure in

the air reservoirs turns the control valve in such a way that air enters the brake cylinders. The force of the air rushing into the brake cylinders pushes the piston forward. A rod connected to the piston operates the brake levers which push the brake shoes against the wheels. Friction between the brake shoes and the wheels really stops the train.

When men learned how to make air brakes, they discovered that air pressure and friction could do work.

THINGS TO THINK ABOUT

1. Why does steam have so much power?

2. How does the speed of Fulton's steamboat compare with the speed of modern steamships?

3. Why are steam locomotives successful while steam automobiles proved unsuccessful?

4. Why did the discovery of America encourage the improvement of transportation?

5. Why would an ocean liner with three or four propellers go faster than a steamship with a single propeller?

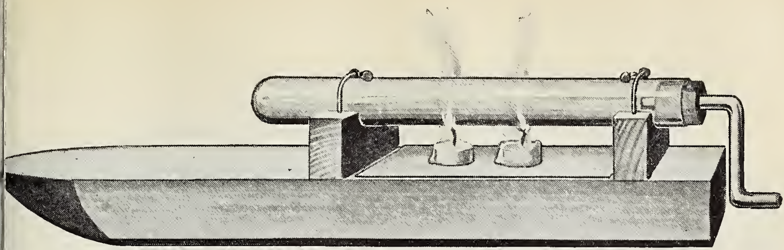
6. Why could paddle-wheel boats be used in streams that are too shallow for boats with screw propellers?

7. In 1809, two years after the *Clermont* made its trial trip, the first Canadian steamboat was launched. This little steamer, called the *Accommodation*, made trips between Montreal and Quebec. Teams of oxen pulled the boat around rapids in the river.

THINGS TO DO

1. Make a small paddle-wheel boat like the one Fulton used when he was a boy.

2. Perhaps you can buy a small steamboat at a toy store. Fill the boiler with water, light the tiny candle, and watch the boat go. The steam rushes out of the tubes and presses back against the water. This backward push shoves the boat ahead.



This is the toy steamboat that is described below

3. If you live near a body of water, you may be able to see an outboard motorboat or a launch. They are pushed through the water by screw propellers.

4. Make a steamboat. Cut a piece of wood into the shape of a boat. Nail two blocks onto the deck of your boat. The blocks should be about four inches apart. One should be nailed onto the stern and the other nearer the bow. These two blocks will hold a test tube which is used for a steam boiler. For this reason it will be necessary to pound two nails on the top of each block, and bend the nails so they will hold the test tube in place. Two lighted candles placed under the test tube in the space between the two blocks will serve as a firepot. The flames of these candles should touch the test tube. Bend a piece of glass tubing into the shape of a crank. Place one end of the glass tubing into a one-hole stopper. Fill a test tube partly full of water. Insert the one-hole stopper into the test tube. Lay the test tube across the two blocks on the deck of your boat. The top of the test tube should be placed at the stern of the boat in such a way that the glass tubing will extend over the stern and into the water in which you are going to operate your boat.

Fasten the candles you have cut to the correct heights on a metal cover. Place the candles between the two blocks under the test tube.

The boat is now ready to be placed in a pan of water. Light the candles. In a few moments the water in the test tube will boil. Steam will rush out of the glass tubing at the stern of your boat, and the boat will start moving. What makes this boat go?

Can you tell why some railroads use electric engines?

Galloway

Travel by Electrical Power

SOME OCEAN LINERS RUN BY ELECTRICITY

Ocean liners have power plants in which they make their own electricity. The electricity made by these power plants is used for many different things. The ships must have electrical power to work the water pumps and electrical appliances and to light their electric lamps.

Some ocean liners run by electricity instead of by steam power. The electricity made in the generators on these ocean liners furnishes the power needed to turn an electric motor. The electric motor turns the propeller shaft.

Every year more and more ocean liners that run by electricity are being built. Today some of the largest ocean liners are moved by the power from their own electric power plants.

SOME TRAINS RUN BY ELECTRICITY

Some trains run by electricity. You may have ridden in electric cars that run on rails much like railroad tracks. Some of you may also have taken a ride on electric cars that run on rails laid in subways, or you may have ridden on elevated electric railways. These electric cars get their electricity from electric power lines.

Sometimes the electric current runs through wires strung on wooden or steel poles above the ground. Sometimes the electric current runs through a third rail. Most elevated cars and subway cars have a heavy metal plate called a shoe. This shoe slides along on the third rail. The electricity which flows into the shoe furnishes the power that turns the electric motor. The electric motor makes the wheels go around.

There are a number of reasons why electric locomotives are used instead of steam locomotives in large cities. They can be started and stopped much easier than steam engines, because they weigh less. They are cleaner and quieter, and they do not take up space that is needed for buildings, because they run underground.

You have probably heard about the streamlined trains that are being built. Some of the fastest streamlined trains make their own electricity. Oil-burning engines furnish the power to turn the generators on these locomotives.

In the future electric trains may be used in place of steam trains.

THINGS TO THINK ABOUT

1. Why could not steam locomotives be used on underground railways?

2. Why is it an advantage in large cities to use trains that can be stopped and started easily?

3. Why are men so interested in building engines that do not scatter cinders and smoke?

Travel by Gasoline and Oil Power

MAN INVENTS THE AUTOMOBILE

The first automobiles looked very much like buggies. They had no gear shifts and their brakes were very poor. It was hard to get the engine running and almost as difficult to get it to stop. No wonder people shouted at the daring men who drove these queer buggies, "Get a horse!" You were much more likely to arrive home safely if you used a horse in those days.

In 1895 there were only four automobiles in the United States. Think how many automobiles there are in the United States today!

The automobile has done a great deal to change the life of modern man. Fifty years ago only a very few city streets were paved. Today we can travel from place to place at a very low cost and with high speed. Farmers can drive into town more easily, and city people can get into the country. The automobile has made it possible for us to travel wherever highways are built.

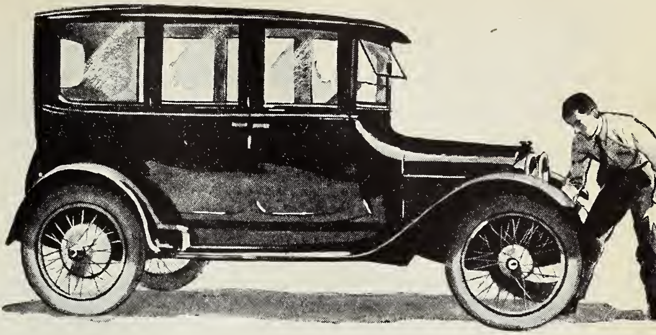
WHAT MAKES THE AUTOMOBILE GO?

A starter, or crank, whirls a flywheel that connects with the piston rod of each cylinder. The whirling flywheel pulls the piston down and up again. As the piston moves down, gas and air rush into the cylinder. As the piston moves upward, it compresses the gas and air. A spark from the spark plug explodes the gas and air. The force of the explosion moves the piston downward and jerks the flywheel around. A flywheel is a very heavy wheel whose motion cannot be easily changed; so it keeps the engine running smoothly.

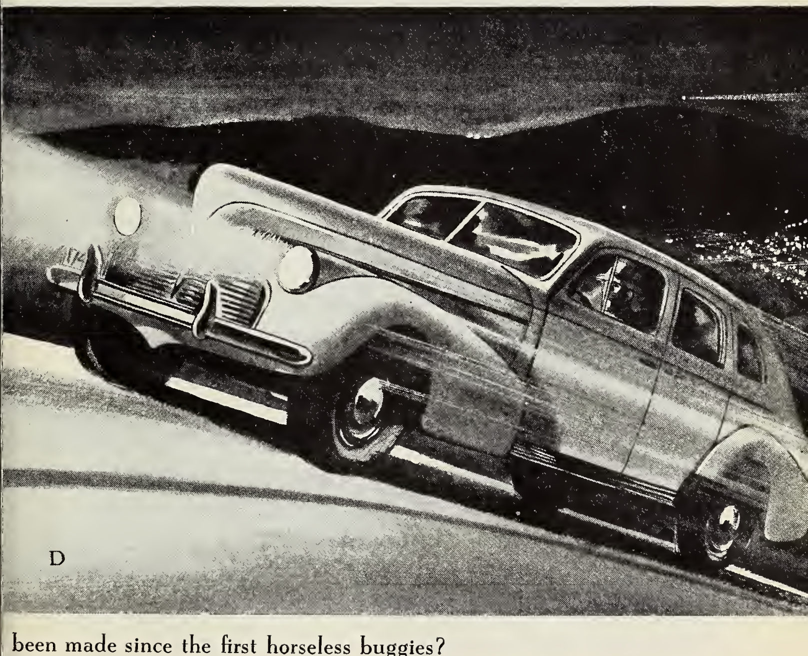
A

B

How many changes can you see that have



C



D

been made since the first horseless buggies?

The flywheel moves the piston rod up and down and up again, and then the next explosion takes place.

A long rod connects the piston rod to a shaft. The other end of this shaft is fastened to the rear wheels of the automobile. As the long rod moves up and down, it whirls the shaft, and the shaft makes the wheels go around.

MAN INVENTS THE AIRPLANE

The first men who tried to fly used gliders. They fastened large wings of different shapes and sizes to their bodies and glided from the tops of roofs and hills. Soaring through the air was great fun, but the landing was not so pleasant.

Many years later two brothers, Wilbur and Orville Wright, became interested in trying to fly. When they were very small boys, their father brought home a toy flying machine. The toy was soon broken, but the boys had got an idea. They wanted to make flying machines. By this time the steam engine and other fuel-burning engines had been invented.

Wilbur and Orville Wright experimented for many years. They made kites and flew them in order to learn more about the air. They read the things that other men who had tried to fly had written.

The brothers worked very quietly and said very little about what they were trying to do. They set up a bicycle shop in which they could earn their living, and made gliders during their spare time. They took their gliders to Kitty Hawk, North Carolina, for test flights, because the winds in Kitty Hawk were good for flying. They made many trial flights with their gliders in order to learn more about the problems of keeping a plane in the air.

© H. D. Jones from Fotograms

One of the Wright brothers making a heavier-than-air glider flight at Kitty Hawk, N. C.

After the Wright brothers had worked with gliders for a number of years, they decided to make an airplane. They worked for more than a year, building a small gasoline engine and fitting it into an airplane.

In December, 1903, they made their first successful flight in an airplane at Kitty Hawk. It was the first successful flight that had ever been made in a heavier-than-air machine. They made two more machines, and after many trials, one of the brothers kept the machine in the air for thirty-eight minutes.

In 1908 Orville Wright made a trial flight before a small audience. People watched him breathlessly. Much to his surprise and more to the surprise of the people below him, he remained in the air for an hour and fifteen minutes. This

wonderful news was telephoned to Washington, D.C., and from there it quickly spread all over the world. At last man had learned to fly.

Less than twenty years after the Wright brothers made a nonstop flight of one hour and fifteen minutes, Colonel Charles Augustus Lindbergh made a nonstop flight of thirty-three hours and thirty-two minutes. He thrilled the world when he faced the dangers of the Atlantic Ocean alone in his transatlantic flight in 1927.

Five years after Lindbergh made his solo flight, Amelia Earhart Putnam flew to Ireland. She was the first woman to cross the Atlantic alone.

Since these famous flights were made, nonstop records for airplanes have been broken many times. Men have flown around the world in a few days. Admiral Richard E. Byrd has flown over the north and south poles.

Although men have learned much about building and flying airplanes, the history of airplanes is still being made. There are many improvements that must be made. In the future more of the world's trade and travel will probably be done in the air.

WHAT KEEPS AN AIRPLANE IN THE AIR?

If you have watched an airplane soar above you and disappear in the clouds, you may have wondered what keeps it in the air. An airplane can fly in the air if it goes at a speed of fifty miles or more an hour. An airplane is so built that when it goes at a certain speed, the air underneath the plane pushes with more force than the air above the plane. In order to understand what keeps an airplane in the air, it is necessary to know something about the way in which an airplane is built.

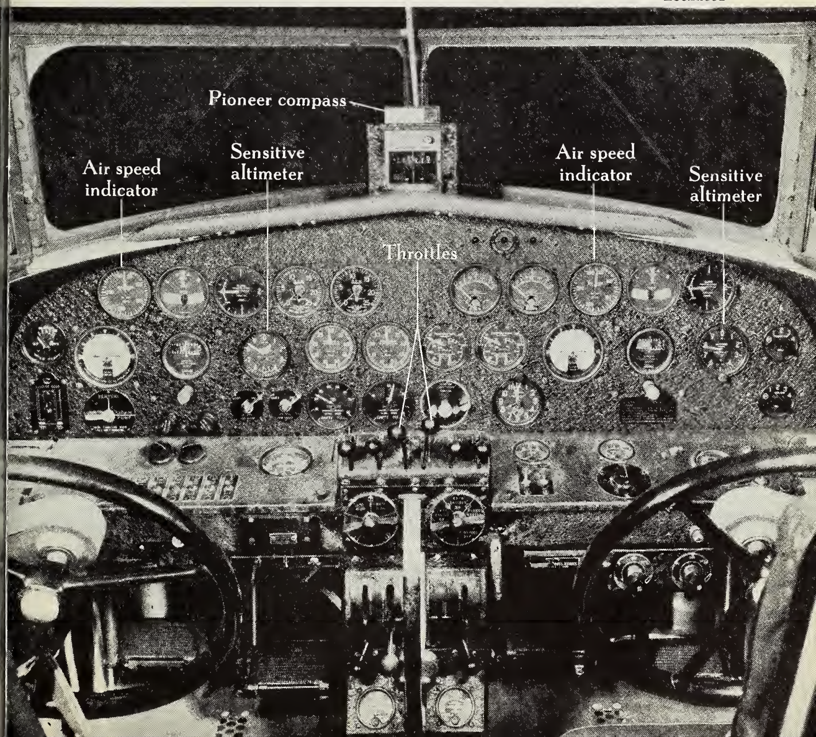
The fuselage, or body of the plane, is made of duralumin. This metal is almost as light as aluminum, and it is much stronger.

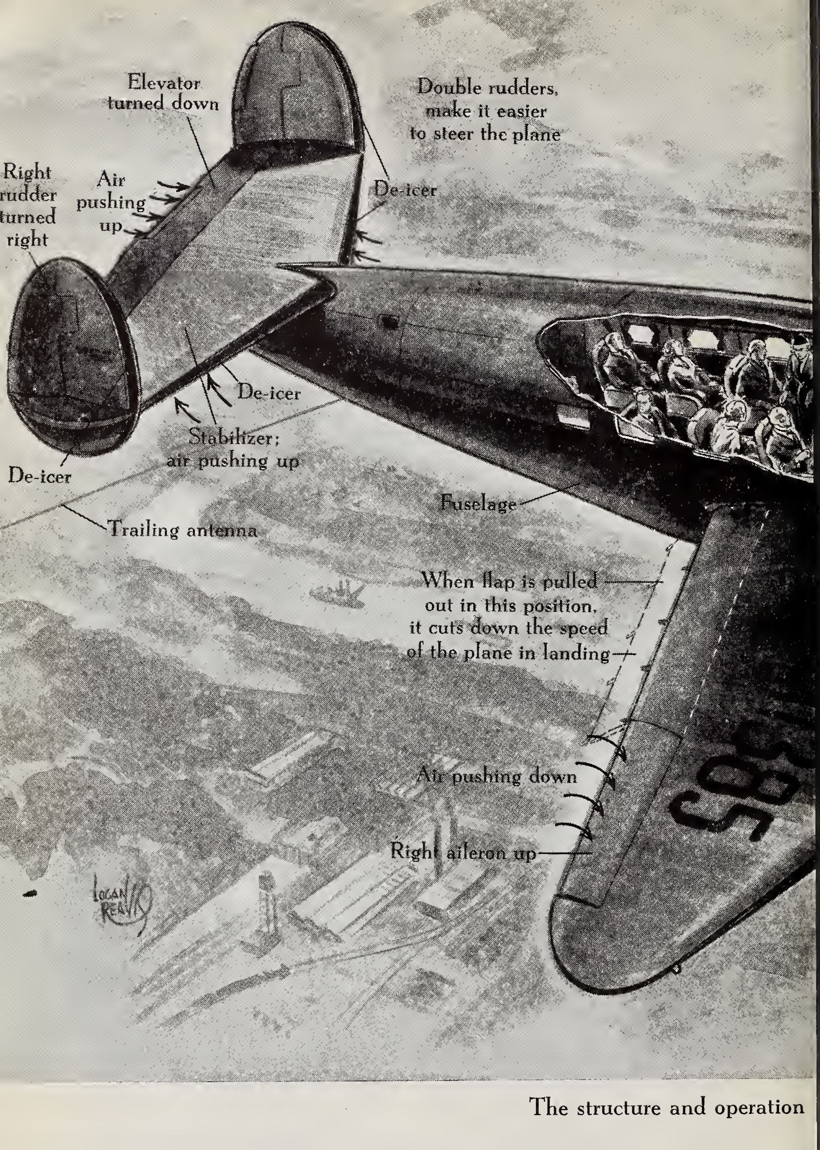
On each side of the tail of the fuselage there are small movable wings called horizontal stabilizers. The stabilizers help to balance the plane.

Hinged to the back of the horizontal stabilizers are two elevators. The elevators help the plane to go up or down. Air pushes against the bottom of the elevators when they are lowered and lifts the tail of the plane upward. This makes the nose of the plane point downward. Air presses down on

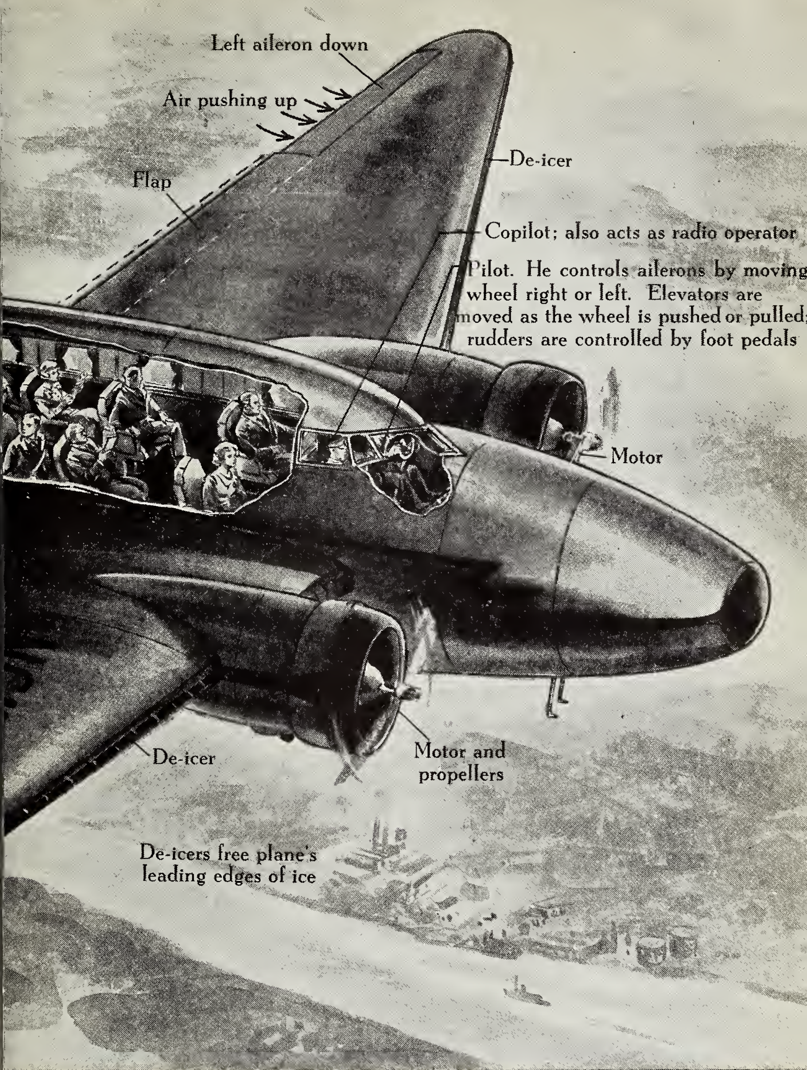
The instrument board of an airplane

Lockheed





The structure and operation



of a passenger airplane

the top of the elevators when they are raised and pushes the tail downward. This makes the nose of the plane point upward.

The movable rudder and vertical fin rest on the top of the tail of the fuselage like a fin on the tail of a fish. The rudder steers the airplane and helps to turn it. When the rudder is turned to the right, the plane turns to the right, because air pushes against the right side of the rudder with greater force than it does on the left side. The vertical fin, or front part of the rudder, divides the air that rushes back over the tail. This prevents the air from spilling off on one side and tipping the plane.

The wings are so built that they force the air away from the top of the plane. This leaves a space on the top of the wings where there is very little air. For this reason there is less air pressing down on the top of the wings than there is underneath. If an object is pressed harder from below than it is from above, it will stay in the air.

The faster a plane speeds through the air, the higher it can climb, because the air rushes underneath it with more force and pushes the plane upward.

A part of the rear end of the wings is hinged so that they can be moved up or down. These hinged parts of the wings are called ailerons. The ailerons help to bank, or tip, the plane when it is turning. If the left aileron is up, and the right aileron is down, the plane tips to the left, because the air rushing over the top of the plane strikes against the left aileron and pushes the wing downward. Ailerons also help in balancing the plane when it is speeding straight ahead.

The propeller of an airplane is like a giant screw. The blades of a propeller are twisted so that they can bore their way through the air.

The wings of a plane keep the plane in the air when it is going at a certain speed. The rudder and the ailerons help to steer it, and the propeller makes it go ahead.

MAN BUILDS SHIPS THAT ARE LIGHTER THAN AIR

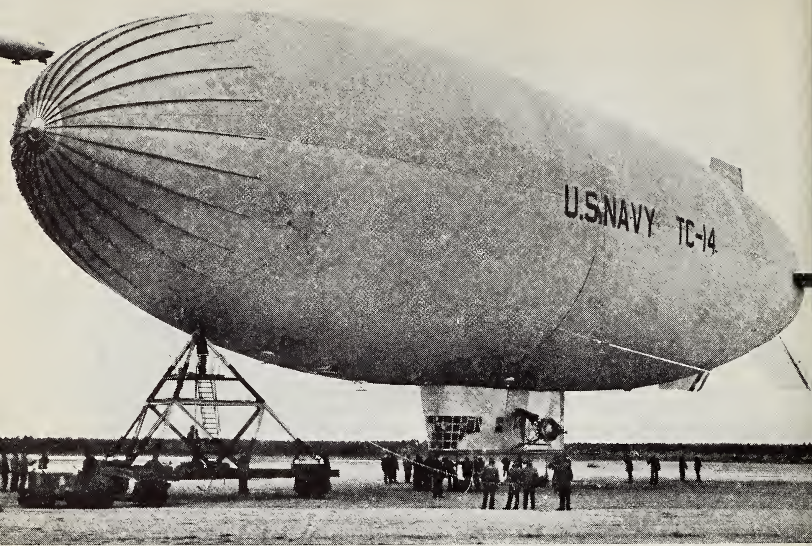
Airships are so made that they are lighter than the air which they push out of the way. The frame of an airship is made of duralumin. This duralumin frame is painted with several coats of a material that will not burn easily. The outer coats are painted with waterproof aluminum paint. A smooth aluminum-coated airship takes in very little of the sun's heat. This helps to keep the ship cool and prevents the gas inside the airship from expanding.

Inside the airship there are a number of gas bags. These bags are filled with a gas called helium. Many small gas bags are used instead of one large bag, because if a bag should be broken, only a small amount of helium would be lost.

The height at which an airship floats depends upon the amount of helium it carries. The gas bags in an airship are only partly filled with gas, because as the ship floats higher and higher there are fewer molecules of air pressing against the ship. When the molecules of helium are not pressed so hard, they spread farther and farther apart. As the helium expands, it fills the gas bags.

When the pilot of an airship wants to moor his ship, he starts a pump, which forces some of the gas out of the gas bags into a storage cylinder. As the gas leaves the bags, air enters. This makes the ship heavier and so it comes down.

Airships are driven by gasoline engines. These engines whirl huge propellers that drive the ship through the air.



Official photograph, United States Navy

First flight from Lakehurst ready to take off from mobile mooring mast

Airships are steered by turning the huge rudders at the rear of the ship. These rudders steer the airship much as the rudders on an ocean liner steer the ship on the sea.

Airships that have frames are called rigid airships, or dirigibles. Dirigibles are better passenger ships than balloons. Balloons cannot be steered. They are blown about by the wind. A streamlined rigid airship can be steered straight into a headwind. Rigid airships may be used a great deal in the future for carrying passengers and light freight.

Man is only beginning to learn to use the air for travel. In the next fifty years you will see many changes in air transportation.

THINGS TO THINK ABOUT

1. Why did the invention of automobiles encourage people to build better roads?

2. How can roads be improved to prevent accidents?

3. What is the difference between gliders and airplanes?

4. What gave man the idea that he might be able to fly?

5. Why did not men invent the airplane a long time ago?

6. Why are the fuselages of some airplanes made of duralumin?

7. Why are not the bodies of airships painted black?

8. What is the latest great event in flying?

THINGS TO DO

1. Name new industries that have come as a result of our new ways of travel.

2. Explain how the gas engine works. Show in what ways it is different from the steam engine.

3. Read more about the inventions of the automobile and the airplane.

4. Make a small airplane.

5. If you live near an airport, ask your teacher to take your class there for a visit.

XIV

Man Learns about Himself

SUNLIGHT HELPS TO BUILD STRONG BODIES

THE FUEL THAT KEEPS THE BODY AT WORK

KEEPING THE BODY AT WORK

STAMPING OUT DISEASE

DURING the past one hundred years men have learned many important things about the human body and what it needs in order to grow properly and do its work. The body needs many different kinds of foods to help it to build cells, take oxygen from the air, fight diseases, and carry off wastes. It also must have enough sunshine, rest, and exercise.

The causes of certain diseases and the cures for them have been found. These discoveries have largely been made by people who have been willing to sacrifice their lives as well as their time and money. Scientists lived for many months in lonely swamps far from any village, searching for the carrier of the malaria and yellow-fever germs. When these scientists found that mosquitoes carried the germs, they spent many more months trying to find a way to kill the germs after they got into the human body.

In times past diseases spread through entire villages, because people did not know how to prevent them. Today we know many of the ways in which diseases are spread. Better still, we now know how to save people from having many different kinds of diseases. In this story you will read some of the things that men are learning about themselves.

THE PICTURE ON PAGE 431 IS BY DE ZAYAS FROM COLLIER'S.

Sunlight Helps to Build Strong Bodies

WHAT SUNLIGHT DOES FOR OUR BODIES

So long as people continued to wander with their animals over pasture lands of warmer countries, they had as much sunshine as their bodies needed. But as they migrated with their animals to countries that were farther north, they could not live as they had in the past. They found it necessary to build warm homes for themselves and their animals to live in during the long winter months. Both men and their animals were spending less time in the open than they had in the past.

As a result of this change new problems had to be solved. Farmers who lived in certain parts of the temperate zones watched their animals become crippled from a very strange disease called rickets. The teeth of these animals became soft and crumbled, and their bones bent out of shape. Baby chickens that had rickets wobbled about the henyard on their crooked legs. These chickens did not grow so big as those that were well.

Children, as well as young animals, were crippled by this disease. It took a long time to find what caused rickets and how to cure this disease.

Animals that were strong and sturdy were used for experiments as well as animals that were ill. The sick animals grew worse during the cold winter months. But only very few of the animals that were kept out of doors for a few hours each day during the cold weather had rickets. For this reason men decided that their animals needed more sunlight.

After these discoveries were made, the question arose as to what was in sunlight that could prevent disease. It was

discovered that very short waves of light in sunlight help to prevent rickets. These short waves of light are called ultraviolet rays.

During the wintertime, in certain parts of the North Temperate Zone, many of the ultraviolet rays in sunlight are lost before they reach the earth. At this time of the year most of the ultraviolet rays never touch the solid part of the earth at all.

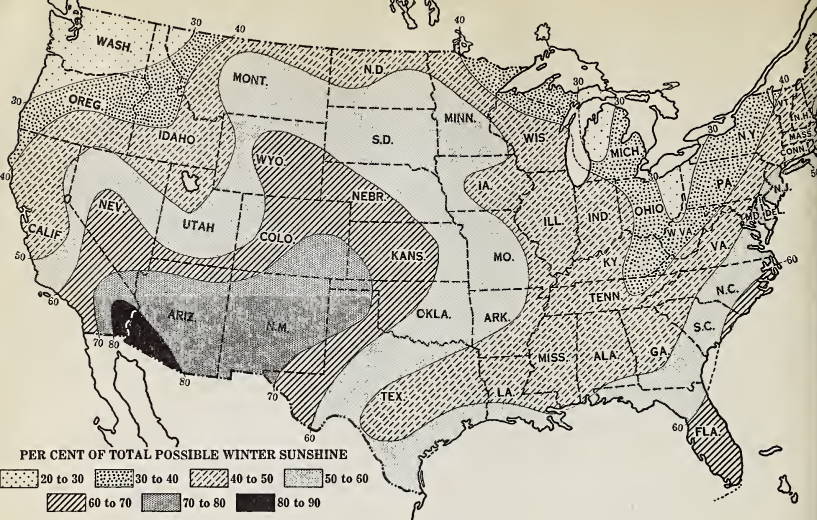
These rays help the body to build a material called vitamin D. You have probably heard your parents talk about vitamins. There is very little known about what vitamins are. Much more is known about what they do for the body. The body must have vitamin D to build strong teeth and bones.

Many of the discoveries human beings have made about themselves were first made by studying the animals they were raising. When it was found that rickets could be prevented by keeping animals outside in the sunlight, people began to wonder if more sunlight would help to prevent the disease in themselves too.

Some persons were living in regions on the earth where it was almost impossible for them to get enough sunlight. Some of these persons had rickets, but people living in other sections did not. It was discovered that the people who did not have rickets were eating more fish and eggs. This gave men the idea that certain foods might be used as a substitute for sunshine.

MAN FINDS SUNLIGHT SUBSTITUTES

You may be living in a section of the world where there are not enough ultraviolet rays to keep your bones and teeth



Is it possible for you to get enough sunshine in winter?

strong and sturdy. The map above will show you whether you are living in one of these sections. If you are living in a section shaded with dots, you may need to talk with your doctor about the best way to get a sunshine substitute during the winter months.

For many centuries it was thought that meat, vegetables, grains, and milk were the only foods the body needed. But we now know that these foods do not have enough of the vitamin which the body needs for building bones and teeth.

The oils of fishes and the yolks of eggs are about the only foods that can be used as sunshine substitutes. These foods supply the body with vitamin D. Sunshine makes vitamin D form in the body. Fish oils and the yolks of eggs have this vitamin in them. Cod-liver oil and other fish oils are often called canned sunshine because they may be used as sunshine substitutes.

THINGS TO THINK ABOUT

1. Cotton clothes allow more ultraviolet rays to pass through them than silk or woolen clothes do. That is why it is important to wear cotton clothing in the summertime.

2. During the long winter months the skin of some people who are living in the North Temperate Zone and the South Temperate Zone becomes very sensitive to sunlight. These people should not stay out in the sunshine for too long a time.

3. Ultraviolet rays gradually make the skin brown if the skin can take them in for a few minutes each day. If the skin receives too many ultraviolet rays at any one time, these rays will burn the skin. Germs may cause an infection in the burnt flesh.

4. We get more ultraviolet rays in sunlight between the hours of 10 A.M. and 1 P.M.

5. Rickets occurs almost entirely in the North Temperate Zone and South Temperate Zone. Most people who live in the tropics get enough sunlight to protect them from this disease. The people living in the arctic and antarctic regions eat fish oils; so they get vitamin D from foods.

6. Ultraviolet rays cannot pass through air that has large amounts of smoke in it.

7. Ordinary window glass filters, or strains out, the ultraviolet rays in the sunlight that passes through it.

8. Animals get vitamins A and D from the green plants they eat, or from the milk, oils, and eggs of animals that eat green plants.

THINGS TO DO

In the summertime the sun's rays are less slanting than they are in the wintertime. The sun's rays pass through the most air before they reach the ground during the winter months and the least air during the summer months. Use an earth globe and an electric light for the sun. Carry the globe around the make-believe sun, keeping the north pole of the earth pointing toward the north as you go around. Notice when the sun's rays will fall directly on the region where you live. This will be the season when you will get the most ultraviolet rays.

Wilson

These children have selected the kind of food their bodies need

The Fuel That Keeps the Body at Work

MAN LEARNS THAT HIS BODY NEEDS CERTAIN MINERALS

There are a number of minerals found in the different parts of the body that help the body to grow and do work. The body must get these minerals from different kinds of foods. Most of these minerals are found in meat, fresh fruits, and vegetables. But the minerals calcium, phosphorus, and iron are found in only a very few foods. For this reason it is necessary to choose foods that have these minerals in them.

When men were studying the cause of rickets, they found that certain kinds of food as well as sunshine helped to prevent rickets. They wanted to find out why these foods helped to build strong bones and teeth. Foods that have the minerals calcium and phosphorus in them are bone-building materials. You will find a list of foods that have a great deal of calcium and phosphorus in them on page 444.

Our bodies depend upon the blood to take oxygen from the air. If the blood is to do this work, it must have iron. The best way to keep the body supplied with iron is to eat foods that have iron in them. You will find a list of foods that have iron in them on page 445.

MAN LEARNS THAT HIS BODY NEEDS VITAMINS

As men continued to study about foods, they learned that foods have different kinds of vitamins in them. A healthy body must have these substances every day. You need more foods rich in vitamins than adults do, because you are still

growing. Your body must have enough vitamins to change the minerals calcium and phosphorus into bones and teeth.

However, even though the body has grown as much as it will ever grow, it still needs foods that have vitamins in them to keep up body repair. The vitamins in foods help to build cells. Whenever we move, eat, sleep, or just sit, old body cells wear out. Vitamins help to build new cells to take the place of body cells that wear out.

Men have also discovered that the body needs the vitamins in different kinds of foods for other purposes than helping it to grow and to keep up repairs.

It is important to eat foods that contain vitamin A, because this vitamin helps the body to fight germs which cause nose, throat, ear, and eye diseases. Vitamin A is found in milk, butter, cream, green parts of plants, liver, cod-liver oil, egg yolks, and carrots.

Vitamins B and G help the digestive organs of the body to work better. When your body has enough of this vitamin, you feel so well that you want to do things. Vitamins B and G are found in yeast, eggs, peas, beans, and whole grains.

Vitamin C helps to prevent tooth decay and kills germs that cause infections in the lining of the digestive organs. Vitamin C is so common in many fresh fruits and vegetables that you would think you would be certain to get enough of this vitamin. But much of it is destroyed when the fresh fruits and veg-

These rats are the same age. Their difference in size is caused by the kind of food they ate. The small rat had no green vegetables and no milk. The large rat had plenty of these foods besides having bread, butter, and meat that was fed to both rats

United States Bureau of Home Economics

etables are cooked. Tomatoes, canned or fresh, oranges, lemons, grapefruit, and raw or cooked potatoes are good foods to eat in order to get vitamin C.

You never worry about bleeding to death because the dentist has pulled out a tooth. You know that your blood will clot, or thicken, in the places where the flesh is torn. It has been discovered that the body needs vitamin K in order to build the substance that causes blood to clot. Most people do not have to choose foods that contain large amounts of vitamin K because it is present in smaller amounts in many foods. But, when a person is too ill to eat or when a person's body cannot make use of the vitamin in such small amounts, it is necessary for him to eat such foods as fish, meat, or alfalfa.

MAN LEARNS THAT HIS BODY NEEDS PROTEINS

As men learned more about foods, they found that some parts of the body would not be properly fed even though they had enough minerals and vitamins. They found that the body needs certain kinds of building materials. These building materials are called proteins.

Eggs, meat, milk, and most nuts are called protein foods. There are hundreds of different kinds of proteins. These different kinds of proteins are necessary for cell-building. Milk, eggs, meat, peanuts, and soybeans contain the important building proteins.

Whole-wheat bread, milk, lettuce, liver, and cod-liver oil sound like a rather simple meal. But a twenty-course banquet could not furnish the body with better food.

THINGS TO THINK ABOUT

1. People who own cars often have their cars looked over in order to see if they need repairs. Our body machines, too, should be looked over by a doctor every few months to see if they need special care.

2. What changes do you make in your winter diet that will take care of the vitamin which sunshine makes?

3. Some cows give milk that is richer in vitamin D than the milk of other cows, because they are out in the sunshine for longer periods of time and are fed foods rich in calcium and phosphorus.

4. Some persons need more of a certain kind of food than others. No two people are exactly alike. A diet that suits the needs of one person may not suit the needs of another person. If a special diet is needed, a doctor should plan it.

5. Half a loaf of whole-wheat bread and a head of lettuce are much cheaper than a pound of beef, and they contain more proteins.

6. A quart of milk for each child and a pint of milk for each adult daily will provide them with all the proteins they need.

7. The habit of emptying the bowels immediately after breakfast is a good one.

8. Although the body contains less than one tenth of an ounce of iron, it is very important that the body should have about that much.

9. These foods contain phosphorus:

codfish, fresh	buttermilk	beef, lean	celery
haddock, fresh	cauliflower	rhubarb	spinach
cheese, cottage	asparagus	cabbage	lettuce
cheese, hard	beans, dried	egg yolk	milk
beans, string	peas, dried	tomatoes	turnips

These foods contain calcium:

celery	cheese, hard	carrots
cauliflower	milk	blackberries
buttermilk	cabbage	strawberries
spinach	beans, string	onions

These foods contain iron:

spinach	tomatoes	onions
beans, string	carrots	raisins
cabbage	peas	figs
beef, lean	potatoes	oatmeal
celery	beets	prunes
egg yolk	turnips	milk
strawberries	bread, graham	bread, white
beans, dried	grapes	

THINGS TO DO

1. What illnesses have you had recently? What changes should you suggest making in your diet that might help to prevent such illnesses?

2. Invite a doctor or a nurse to talk to your class about the ways in which different kinds of foods help to prevent such illnesses as the common cold, earache, sore throat, and influenza.

3. People who know a great deal about the foods that the body needs made these suggestions:

a. Drink at least one quart of milk a day.

b. Eat at least one large serving of some vegetable other than potatoes twice a day.

c. Eat a potato or some other vegetable in its place once a day.

d. Be sure you have some vegetable or fruit rich in vitamin C each day.

e. Eat at least one egg daily.

f. Eat another egg, cheese, meat, fish, or nuts once a day.

g. Eat a whole-grained cereal.

h. Eat several slices of bread. Whole-wheat bread is better for most people than white bread, because the hull, or outside cover, of the grain is rich in calcium.

i. Foods digest better if they are eaten when you are rested and if you eat slowly.

Keeping the Body at Work

MAN LEARNS THAT HIS BODY SHOULD DO WORK

For many centuries men thought that only people who wanted to develop the muscles of their body should exercise. Now we know that exercise is more than a muscle-builder. It helps to keep the whole body growing and working better.

Exercise keeps the heart strong. It makes the heart pump faster. When the heart pumps faster, the lungs take in more air and get rid of the air faster. This brings a richer supply of oxygen into the lungs. For this reason the blood flowing through the blood vessels in the tissues of the lungs can carry more oxygen to the cells of the body. When there is more oxygen present in the blood, the body can digest its food better.

Exercise helps the body to get rid of waste materials. You have probably noticed how much more you perspire when you are running or jumping than when you are sitting still. When the body perspires freely, it keeps the pores of the skin open. This makes it possible for waste material to pass through these pores.

After sitting still in school it is very necessary to be out of doors exercising the large muscles of the body either in work or in play. Strong shoulder muscles help to hold the chest in the right position so that the lungs will have room enough to move easily. Playing tennis or baseball, rowing a boat, paddling a canoe, sweeping, pushing the lawn-mower, hoeing, and raking help to develop the shoulder muscles.

Strong trunk muscles help the body to stand and sit correctly. This is important, because the organs that digest

Coons

Helping with garden work makes the body work better

food and carry away wastes are in the trunk of the body. These organs need enough room to carry on their work. Strong trunk muscles help to keep the organs of the body in place. They also prevent the walls of the body from crowding against these organs that digest food and carry away waste material. Men have learned that it is important to exercise these muscles every day.

Our bodies get the most good from exercise that we enjoy. Food digests better. The organs of the body work better when we are doing the things we like to do. After a good night's rest the body should be exercised. It does not matter whether we exercise in work or play, so long as we are having fun.

THINGS TO THINK ABOUT

1. Children have less work to do today than children a hundred years ago. In those days some children spent such long hours working in the field, mines, factories, and homes that they were too tired to play games, run, and jump as children do today. Imagine a child sitting in front of a spinning wheel all day. What muscles would the child be using? What important muscles would not be used? Many children who lived a hundred years ago did not have so good a chance to grow strong and sturdy as children do today.

2. It is important to wear the right kind of clothes. Play suits are good to wear when working in the garden or playing games. Thick-soled shoes and heavier clothing should be worn on hikes. In order to have fun we must be able to forget everything but the things we are doing.

3. People need to spend a certain number of hours in sleep in order to let their body catch up on its repairs. Every time we move, cells wear out. In the daytime we are so much more active that new cells cannot grow so fast as the old ones wear out. While we are sleeping, some parts of the body slow down. During this time cells are built faster than they are worn out.

Stamping Out Disease

WHAT ANCIENT PEOPLE THOUGHT ABOUT DISEASE

Ancient people in various parts of the world had many ideas about diseases and how to cure them.

Some people believed that sickness was caused by demons, or evil spirits, which came to live in the body. If you had been sick in those days, you probably would have thought that an evil spirit was inside you. Your friends might have felt sorry for you and tried to cure you. Do you know what they might have done? They probably would have put on ugly masks and would have danced about you, making loud and terrifying noises to frighten away the evil spirits. Or they might have called their medicine man, who would have used charms or magic to make you well.

Sometimes people kept horrible statues, or images, in their homes to frighten away evil spirits. Even now there are people who believe that a rabbit's foot or some other charm can keep bad luck away. Of course nearly everyone living today knows that a charm cannot cure or prevent a disease.

The Greeks believed that a doctor had to study the stars before he could give his patient medicine. These people of olden times thought that the signs of the zodiac ruled certain parts of the body. The zodiac is an imaginary belt that stretches across the sky from east to west. The zodiac has been divided into twelve parts. These parts are called signs, which were named after the twelve constellations that appear in this belt during certain seasons of the year. The larger planets also appear to move across this section of the sky. People believed that those who had weak stomachs should

eat only the simplest foods during the time that the sign of the zodiac that ruled the stomach was in the sky. They thought that persons who had weak chests should live wisely during the time that the sign that ruled the chest was in the sky. They believed that when the different constellations in the zodiac appeared near the moon they caused certain kinds of illnesses.

Imagine that you were living during the time when these things were believed. Let us suppose that you ate too many green apples and had a bad stomach-ache. Unless the moon happened to be near the sign in the zodiac that ruled the stomach, you would not have been given castor oil. If the moon happened to be near the sign of the zodiac that ruled the feet, your mother or the doctor would have given you medicine for foot trouble.

Is it any wonder that people in times long past thought illness was a punishment sent down by the gods? Some persons even thought that it was wrong to try to help those who were sick. They believed that the gods wanted these people to be ill.

Hippocrates, a Greek physician, who lived more than two thousand years ago, had still another idea about the cause of disease. He believed that people had four different humors, or liquids, in their bodies. He imagined that a person who was ill had either too much of one humor or too little of another. We still speak of being in a good humor or in a bad humor, even though we know that Hippocrates' belief was wrong.

MAN'S IDEAS ABOUT DISEASES HAVE CHANGED GREATLY

When a few men no longer believed that diseases were caused by spirits or the gods, they tried to find out what really caused diseases.

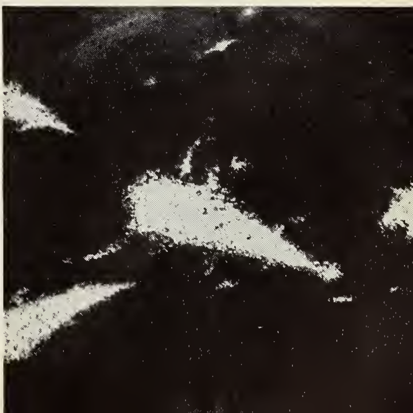
Less than one hundred years ago it was learned that some illnesses are caused by tiny plants and animals. Since that time it has been discovered that more than three fourths of the known diseases are caused by these tiny living things.

Small plants that cause disease are called bacteria, or germs. The tiny animals that cause disease are called protozoa, and they are also known as germs.

Disease germs are so small that they cannot be seen without the aid of a very powerful microscope. Many thousands of disease germs can live in one single drop of water.

For nearly a century men have been trying to find the causes of different diseases and how they may cure persons who have them. Sometimes the search has been very exciting, but more often it has been both difficult and discouraging. Long tiresome hours have been spent by scientists in laboratories, bending over test tubes, experimenting with this and that material that might kill the bacteria, or germs, which cause disease. By experimenting in this way scientists have been able to find cures for such diseases as diphtheria, scarlet fever, typhoid, chicken pox, and measles.

This picture of many thousands of bacteria was taken with the aid of a camera and a microscope



As more was learned about the tiny plants and animals that cause most diseases, a new problem arose. People began to wonder if it would not be better to try to prevent disease than to wait until disease began to spread and then try to cure it.

HOW DISEASES ARE KEPT FROM SPREADING

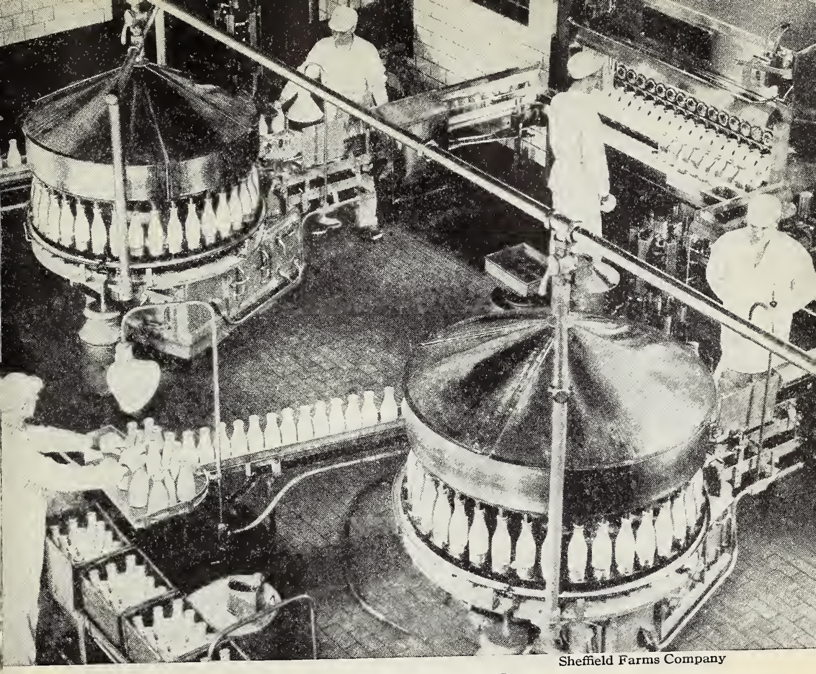
Bacteria and disease germs which cause different diseases may be spread in many ways if they are not checked.

Certain diseases, such as typhoid fever and tuberculosis, are sometimes carried in milk. Sometimes the cow that gave the milk has the disease. Sometimes the people who handled the milk have the disease. For this reason great care should be taken to see that milk comes from healthy cows that are kept in clean barns. All pans, cans, and bottles should be heated very hot to kill all the bacteria.

The safest kind of milk to buy is pasteurized milk. If it has been pasteurized, it is usually free from disease germs. Milk should always be kept in a covered pan or dish to prevent bacteria from getting into it.

Everyone must drink water in order to live. Yet water has been one of the most common ways in which disease germs have spread. Millions of bacteria can live in drinking water. These bacteria can be carried in the water for miles and miles, spreading the disease from one place to another. Water that looks clear and tastes good may carry the dangerous typhoid germs.

From the earliest times wells have been one of the chief sources of drinking water. Nearly all farmhouses and small towns still get their water from wells. Some wells may contain water that is good to drink. Others may contain water


Sheffield Farms Company

Bottling milk in a large dairy

that is filled with harmful bacteria. This depends upon where the well gets its water.

The water that runs into a well is almost entirely supplied by rain. After heavy rains great quantities of water collect in streams and are carried off to rivers, and then to seas, lakes, and oceans. But other quantities of water soak into the soil.

Rain water, before it reaches the ground, is usually free from bacteria; but it does not remain so very long.

Sometimes before the rain water seeps into the earth, it passes over manure piles, garbage, or other waste material. As the water passes over these wastes, it dissolves some of

the waste material and carries it along with it. If this waste material came from animals or people that had typhoid fever, some of the germs may be carried along in the water. If the well into which this rain water runs is very shallow, the persons who drink the water may get typhoid fever. If this water runs into a deep well, the soil may filter, or strain out, the bacteria before the water runs into the well. Deep wells are much more likely to be free from germs than shallow wells.

When people began to live near one another in towns and cities, it became difficult to dig a well for each family. In cities today water companies or the cities themselves supply the water. Some cities that are located on rivers use river water. River water is likely to be dangerous to drink, because people often empty waste materials into it. Disease germs can be carried from one place to another in this way. Therefore care must be taken to make the water safe to drink.

Today many towns and cities that empty their waste materials in rivers also have sewage plants. Sewage plants treat the sewage or waste materials with chemicals that kill harmful bacteria. After this treatment it is safe to empty the sewage in a river that is used for drinking water.

In cities today drinking water is put through several processes to make sure that any disease bacteria in it are destroyed.

First, the water is allowed to stand until the sediment settles to the bottom. Then after the sediment has settled, the water passes through layers of sand and gravel. These layers of sand and gravel are called filters. The filters strain out the finer particles of soil or waste materials.

After the water has been filtered, it is often shot up into the air in fine sprays. This helps to purify the water, because sunlight helps to kill germs. Many cities also add a greenish-yellow liquid called chlorine to the water. Chlorine kills any

germs that may be left after the filtering and spraying process.

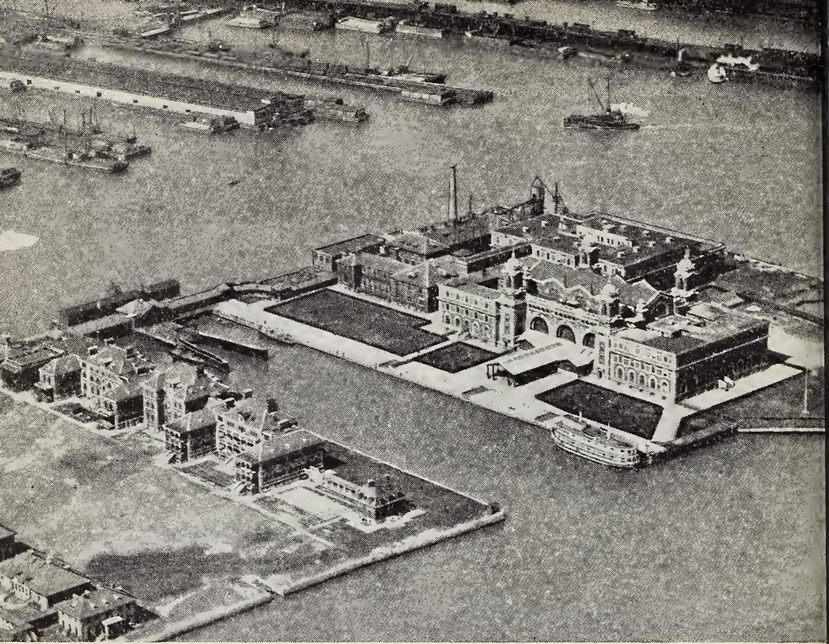
For many years people thought that bad air from the swamps caused malaria and yellow fever.

Now we know that mosquitoes that live in swamps carry these diseases. If a certain kind of mosquito sucks the blood from a person who is ill with malaria, some of the germs in that person's blood will get into the mosquito. When this mosquito draws blood from another person, it will probably leave some of its germs. This second person is almost certain to become ill with malaria. The malarial mosquito spreads the germs from one person to another in this way. Yellow-fever germs are also carried by a certain kind of mosquito.

The germs of malaria fever and yellow fever are tiny one-celled animals, or protozoa. These little animal germs live part of their lives inside the mosquito and part of their lives in the blood of the person bitten by the mosquito.

Malaria and yellow fever may be kept from spreading by getting rid of the mosquitoes that carry the germs. Swamps where these mosquitoes breed are being drained. The water in some swamps is being covered with oil. Oil on the water prevents the mosquito larvae from getting air, and the larvae die. People who are living near the breeding places of these mosquitoes keep their homes screened and place mosquito netting over themselves when they sleep.

Flies help to spread disease. The common housefly has sticky hairs on its feet. If the fly lights on a place where there are disease germs, these germs will probably stick to the fly's feet. The fly may carry the germs some distance before it settles again. This time the fly may walk over food that is to be served. The germs on the fly's feet may stick to the food. The person who eats the food may become ill from the germs.


© Galloway
Quarantine station on Ellis Island, New York City harbor

Because flies often breed in garbage and other refuse, it is very important to see that these waste materials are kept tightly covered until they are carried away. In many cities today the health department sees that the garbage or other refuse is collected several times a week. Either this refuse is burned or chemicals are used to kill any harmful bacteria and then the refuse is dumped into the rivers or lakes.

The tsetse fly is another kind of fly that carries disease. This fly carries the germs that cause sleeping sickness. Fleas, bedbugs, lice, and cockroaches also spread disease from one place to another.

Other kinds of animals may carry disease germs. Rats have been very troublesome. They go on ships and carry disease

germs from one country to another. Devices called rat guards are fastened to the lines that fasten a ship while it is in dock so that the rats cannot go on the ship or get off the ship if they are already on.

Such diseases as smallpox, measles, scarlet fever, mumps, and diphtheria can be carried by people. Persons who are ill with these diseases are kept at home, so that they will not spread the disease to others. Sometimes people who were near the person who has one of these diseases are also quarantined.

Since human beings can spread some kinds of diseases, it is very important that doctors examine persons coming in from another country. Years ago when ships entered certain seaports of the world, the ships were quarantined in the harbor for forty days before anyone was allowed to come ashore. Now when a ship enters a great seaport, like that of Halifax or New York City, it must stop awhile and take inspectors aboard. It takes only a few hours for these inspectors to examine the passengers. Persons who have diseases are held in quarantine.

There are still other ways in which disease bacteria and protozoa are kept from spreading. Some people have tiny things in their blood which kill a certain kind of disease germ. These tiny things in the blood are called antibodies. A person who has these antibodies is said to be immune. This means that he will not take the disease. Some people are naturally immune to certain diseases and others are not. Doctors can help persons who are not immune. A doctor can put substances into the blood that will cause antibodies to form.

Diphtheria is one disease which may be prevented in this way. First, a doctor tests your blood to see if there are any

Rothstein from United States Public Health Service

The doctor is giving the Schick test to find whether this boy is immune to diphtheria

antibodies in it. This is called the Schick test. Diphtheria bacteria give off a poison called a toxin. The doctor puts a small amount of pure toxin into your blood. If nothing happens, you have the antibodies. That means that you probably would not take the disease if you were near a person who has it. In this case you do not need to take any further treatment. But if the place in your skin gets red after the toxin has been put in, that means that you do not have the antibodies in your blood and that you would probably take the disease if you were exposed to it.

If the Schick test shows that you might take diphtheria, the doctor can make you immune to it. He has a substance

called toxin-antitoxin which he puts into your blood. This causes the antibodies to form and makes you immune to diphtheria. The treatment is very simple and is a protection against that disease.

However, even though you have diphtheria toxin-antitoxin in your blood it does not make you immune to other diseases. Every disease that can be prevented has a special method for its prevention. You can be vaccinated against smallpox, and you can have treatments which make you immune to typhoid-fever germs.

Since men have learned how to make people immune to certain diseases, they are able to prevent the spread of these diseases.

In less than a century many of the diseases have been conquered that our grandparents feared. Even now, in different parts of the world, men are at work trying to find new or better ways to cure and prevent illnesses. And today, tomorrow, or in the near future, new discoveries will be made that will help us conquer still other diseases.

THINGS TO THINK ABOUT

1. A reservoir, or place built to catch rain water, is often formed by building a huge dam across a small stream. The water collects behind the dam until it finally makes a large artificial lake, sometimes covering acres of land. Some cities get their water from lakes that are found up in the hills and mountains. Much of the water that supplies New York City falls as rain one hundred fifty miles away.

2. In ancient Rome a great deal of water was used to wash the dirty streets. At this time people did not know how to make pipes large enough to carry much water; so they dug tunnels and lined them with cement. We still call the pipes that carry water from reservoirs to cities by the same name that the Romans used; that is, aqueducts.

3. If you go camping and have to use water from a lake or river, it is always best to boil drinking water for several minutes. However, boiling the drinking water drives out the air and takes away the flavor. Air may be added to the water by pouring the water into a clean bottle and shaking it.

4. Cities and towns have departments of health and other special departments to help in preventing the spread of disease.

5. The Federal government makes pure-food laws and hires inspectors that see that the laws are obeyed. It is most important to us to see that these departments of the government are run carefully and honestly.

THINGS TO DO

1. Perhaps your class can visit the laboratories of your board of health and learn more about the things bacteria need to grow and the ways in which they are destroyed. If you visit a city health laboratory or a hospital, ask the person in charge to let you see some bacteria through a microscope.

2. Read the story that tells how scientists learned that malaria and yellow fever were carried by mosquitoes.

3. Visit the place where your city or town gets its drinking water. How is this water made safe for drinking purposes?

4. What is done with the garbage and other waste materials in your home? Perhaps you live in a city. What methods does your city use to get rid of garbage and sewage?

5. Read the life of Dr. Jenner and tell what he did to prevent disease?

Science Words

This list of science words and explanations may be used as a dictionary to help you in learning the meanings of the science words which are used in your book. When you come to a new word, turn to this list to find the explanation of the word.

The explanations for the words given in this book will not tell everything about them. The authors have tried to give you the kind of information that they think will be most helpful to you now. In your later science work you will learn a great deal more about some of these words.

Some of these words you will find very useful. You will want to learn to use them. See how many of these words you can use at home and at school.

Following the explanation you will find the number of the page where the word is first used in the book. In the index you may find the numbers of other pages on which the word is used.

KEY TO THE SOUNDS

ă *as in* at	ĕ *as in* bet	ō *as in* go	ū *as in* use
ā *as in* ate	ē *as in* be	ô *as in* horse	ŋ *as in* ink
ä *as in* arm	ẽ *as in* her	oi *as in* oil	ŧh *as in* bathe
â *as in* care	ĭ *as in* bit	o͞o *as in* food	zh *like the* s *in* pleasure
ȧ *as in* sofa	ī *as in* bite	o͝o *as in* foot	
	ŏ *as in* got	ŭ *as in* us	

Acid. Acids usually have a sour taste and are often in liquid form. The sourness of vinegar and lemon juice is caused by acids (p. 280)

Aileron. The hinged part of the wing of an airplane which helps to turn and balance the airplane (p. 426)

Alchemists. Men who tried to change common metals into gold and to discover a means by which people might live forever (p. 266)

Alkali. A substance which water dissolves from some rocks. It is used with fat in the making of soap (p. 61)

Allosaurus (ăl ō sô′rŭs). A kind of flesh-eating dinosaur (p. 162)

Alloy. A mixture of metals that have been heated together (p. 275)

Amber. A fossil resin or gumlike substance that was formed by trees many millions of years ago. It is a solid and is clear light yellowish brown in color. Amber is often used for jewelry (p. 337)

Amplified. Made larger. Electrical waves are amplified, or made larger, by a vacuum tube. A loud-speaker amplifies sound waves (p. 381)

Aniline. An oily liquid found in coal tar. Aniline is used to make dyes, medicines, and perfumes (p. 284)

Antibodies. Substances in the blood which prevent people from catching certain diseases (p. 457)

Archaeopteryx (är kē ŏp′tẽr ĭks). A kind of bird which lived long ago (p. 175)

Archeozoic (är kē ō zō′ĭk). A period in the earth's history when life is thought to have begun (p. 131)

Asteroids. A group of very small planets between the paths of Mars and Jupiter (p. 46)

Brontosaurus (brŏn tō sô′rŭs). A kind of plant-eating dinosaur (p. 162)

Bronze. Bronze is an alloy of copper. It consists of eight or nine parts of copper to one part of tin (p. 290)

Caoutchouc (kōō′chŏŏk). A thick, sticky sap of certain trees, which is made into rubber (p. 282)

Carburetor. A device in the engine of an automobile in which air and gasoline vapors are mixed together (p. 334)

Cellulose. A white substance that forms the cell walls of plants. Cellulose is used for making different kinds of cloth (p. 280)

Compound. A substance composed of certain amounts of two or more elements. Water is a compound because it is composed of two different elements, hydrogen and oxygen (p. 273)

Cone-bearing tree. A tree whose seeds are borne in cones (p. 168)

Constellation. A group of stars. The ancients divided the sky into constellations (p. 28)

Coral polyps. The tiny coral animals (p. 129)

Cordaites (kôr dā ī′tēz). Huge trees living in the Coal Age, now extinct (p. 148)

Corrode. Some metals when they are open to air and moisture corrode, or crumble into dust. Iron corrodes into dust (p. 305)

Cycads (sī′kăds). Certain kinds of plants (p. 168)

Cylinder. A hollow metal tube. In the cylinder of a steam engine the steam is applied to the piston and piston rod (p. 329)

Diphtheria. A disease caused by a certain kind of bacteria. These bacteria cause the air passages of the nose and throat to become choked (p. 451)

Diplodocus (dĭp lŏd′ō kŭs). A plant-eating dinosaur (p. 167)

Electrons. Tiny bits of electricity. A generator or dry cell can make electrons move (p. 342)

Element. A substance that may unite with other substances to form compounds. It is made of only one kind of thing. There are ninety-two known elements in the earth (p. 269)

Eohippus (ē ō hĭp′ŭs). The name given to the first horse. *Eohippus* was the ancestor of the horse we know today (p. 193)

Extinct. Anything which lived or was active at some time in the past but now is quiet or no longer exists is said to be extinct. Some volcanoes are extinct. They have not erupted in hundreds of years. Some animals are extinct. Their kinds do not live now (p. 133)

Fahrenheit (făr′ĕn hīt). Most of the thermometers in our homes and schools have the Fahrenheit scale. Water freezes at 32° and boils at 212° on the Fahrenheit scale. F. stands for Fahrenheit (p. 23)

Fertile. An egg or a seed that can grow into an animal or a plant is fertile. Chickens hatch from fertile eggs. Seeds of flowering plants need pollen to make them fertile (p. 231)

Fossil. Any remains left by plants or animals of long ago (p. 107)

Fungi (singular *fungus*). Plants that are not green. Fungi cannot make their own food, but they live on other plants or animals. Mushrooms, molds, yeasts, and bacteria are fungi (p. 231)

Fuselage. The body of an airplane (p. 423)

Galaxy. A very large system of stars. Our sun is in a galaxy called the Milky Way (p. 29)

Galvanometer. An instrument that shows the presence of a current of electricity. It also can be used to show the direction in which the current is flowing and its strength (p. 341)

Geyser. A sudden spurting or bursting of hot water into the air from a deep hole in the earth (p. 74)

Gill. Fish, tadpoles, and many other water animals breathe the

air in water through their gills, as many land animals breathe through lungs (p. 153)

Ginkgo. A kind of tree whose ancestors lived in ages past (p. 170)

Gneiss (nīs). An igneous rock which usually contains mica, feldspar, and quartz minerals in bands (p. 111)

Horizontal stabilizer. Small movable wing built on each side of the tail of the fuselage. The stabilizers help to balance the plane (p. 423)

Hornblende. A dark-colored mineral (p. 102)

Hypothesis. An explanation which may or may not be true. Scientists develop these explanations after a great deal of study. They are willing to accept a better explanation if they discover one (p. 39)

Ichthyosaurus (ĭk thĭ ō sô′rŭs). A kind of flesh-eating dinosaur living in water (p. 162)

Igneous rock. One of three great classes of rocks. Igneous rocks were formed by heat. They were melted at one time, then cooled (p. 108)

Immune. Protected against a disease by a substance present in the body (p. 457)

Insulation. A substance that will not let electricity pass through it. Wires carrying a current of electricity are often insulated with cloth, rubber, paint, or varnish (p. 347)

Invertebrates. Animals with no backbone, such as jellyfish and insects (p. 137)

Jellyfish. A soft-bodied, boneless animal living in sea water (p. 121)

Laboratory. A room in which experiments are made or shown (p. 12)

Larva (plural *larvae*). A period in the growth of certain insects when these insects look like worms. Some larvae are called caterpillars; others are called grubs and nymphs (p. 235)

Lever (lē′vẽr). A kind of simple machine. A crowbar may be used as a lever. Handles of brooms, shovels, rakes, hoes, hammers, and can-openers are levers (p. 286)

Light year. The distance light can travel in one year (p. 27)

Mammal. Any animal whose young is fed on milk (p. 180)

Mammoth. A very large extinct animal related to the elephant (p. 195)

Marsupial. A mammal whose young are carried about in a pouch by its mother (p. 184)

Mastodon. A kind of extinct animal related to the elephant (p. 196)

Metamorphic rock. One of three great classes of rock. A metamorphic rock has been changed by heat and pressure until it is no longer the same kind of rock that it was before the heat and pressure changed it (p. 110)

Meteor. A small object traveling in space. If it reaches the earth's atmosphere, the friction of the air makes it glow as a streak in the sky (p. 14)

Meteorite. A meteor which has fallen to the earth's surface (p. 53)

Mica (mī'cȧ). A flaky mineral with a shiny appearance (p. 101)

Molecule. The smallest particle, or bit, that a substance can be broken into and still exist as that substance. There are many thousands of molecules of iron in the head of a pin that is made of iron (p. 427)

Movable rudder. A movable part at the rear of an airplane or boat. The rudder helps to steer the airplane or boat (p. 426)

Muck. Decayed material (p. 151)

Nebula. A large system of stars or a huge mass of gases (p. 33)

Oxygen. One of the elements. It is a colorless, odorless, tasteless gas found in the air (p. 26)

Piston. A sliding metal rod that is pushed by steam in a steam cylinder and by gas in a gas cylinder (p. 329)

Piston rod. The rod fastened to a piston which moves back and forth with the piston (p. 329)

Planetesimal. A very tiny piece of dust or rock traveling around in space (p. 46)

Pollution. Making or being impure or unclean. If bacteria that cause disease are present in water, the water is said to be polluted (p. 244)

Potash. A compound containing the elements potassium, carbon, and oxygen. Wood ashes contain potash. Potash is used as fertilizer (p. 247)

Propeller shaft. A rod that connects the propeller with the engine of a ship or an airplane (p. 401)

Protein. A substance found in many foods, particularly in our foods that come from animals, such as eggs, meat, and milk.

Foods like flour, beans, and oatmeal also contain proteins, but not so much as the animal foods. It is very necessary that we eat proteins to build up our body tissue. Our body tissues are made of proteins (p. 240)

Proterozoic (prŏt ẽr ō zō′ĭk) *Age.* One of the earliest periods in the earth's history (p. 131)

Protozoa. One-celled animals. Protozoa are the most simple animals (p. 451)

Pterodactyl (tĕr ō dăk′tĭl). A kind of flesh-eating flying dinosaur (p. 163)

Pupa (plural *pupae*). A period of growth of an insect when it rests in a shell or skin. When a caterpillar changes into a pupa, it sheds its caterpillar skin; the skin underneath hardens into a pupa case (p. 235)

Quartzite. A rock made when sandstone was changed by heat and pressure (p. 111)

Reproduce. To have young. If living things did not reproduce, there would soon be no more life on the earth (p. 143)

Reptile. Creeping or crawling cold-blooded animals, such as snakes and alligators (p. 156)

Rickets. A disease occurring in children and young animals. This disease causes the bones and teeth to become soft. It is caused by a lack of calcium, phosphorus, and vitamin D in the diet (p. 434)

Schick Test. A test invented by Bela Schick in 1913. This test is given to discover whether a person is immune to diphtheria (p. 458)

Schist (shĭst). A metamorphic rock made from shale or slate (p. 112)

Scorpion. A kind of invertebrate animal (p. 138)

Screw propeller. The blades fastened on to a rod which can be used to drive a ship or an airplane (p. 401)

Sea anemone. A kind of animal that lives fastened to rocks in the sea (p. 121)

Sediment. When a swift-moving stream flows along, it usually picks up small rocks, sand, and soil. Later the stream may deposit this material somewhere. All such material is called sediment (p. 66)

Sedimentary rock. One of three classes of rocks. Sedimentary rocks are made from sediment which has been pressed, hardened, and cemented together (p. 104)

Seismograph (sīs′mō grăph). An instrument which makes a record of earthquakes (p. 80)

Sequoia. A very large kind of evergreen tree (p. 169)

Sewage. The materials carried off by water through sewers or drain pipes (p. 245)

Shaft. A well-like opening in a mine, the sides of which are supported by heavy timbers, through which ore is brought to the surface (p. 300)

Shale. A sedimentary rock formed out of clay (p. 105)

Solar system. The sun, the planets with their moons, the comets, and other bodies which revolve about the sun form the solar system (p. 23)

Spectroscope. An instrument which men use to study the light from the stars (p. 26)

Spiral galaxy. Any great group of stars which has a spiral appearance (p. 32)

Steam turbine. A wheel that is driven by the force of steam. The steam striking against the curved vanes or cups on the rim of the wheel causes the wheel to whirl around (p. 403)

Stegosaurus (stĕg ō sô′rŭs). A kind of plant-eating dinosaur (p. 162)

Tarnish. A compound made by chemical action. Silver often becomes tarnished by uniting with sulfur (p. 277)

Telescope. A tube containing lenses used to view distant objects (p. 12)

Theory. An explanation which seems to be true and may later be proved true (p. 39)

Thermocouple. An instrument used to measure the temperature of stars (p. 24)

Toxin. A kind of poison that forms in animals when they are ill from certain diseases (p. 458)

Toxin-antitoxin. A substance put in the blood that causes antibodies to form. These antibodies protect the body from diphtheria (p. 459)

Transformer. The force of electricity must sometimes be changed. Sometimes it is increased by a step-up transformer. Sometimes it is decreased, or made less, by means of a step-down transformer (p. 345)

Transmitter. The mouthpiece of a telephone, into which we talk. The transmitter changes the sound waves into electrical waves (p. 391)

Triceratops (trī sĕr′ȧ tŏps). A kind of plant-eating dinosaur (p. 162)

Trilobite (trī′lō bīt). An animal which lived in the seas many ages ago (p. 133)

Tsetse (tsĕt′sē) *fly.* An African fly that carries the germs which cause people to have sleeping sickness (p. 456)

Typhoid. A disease caused by a certain kind of bacteria. It is often spread by infected water and milk (p. 452)

Tyrannosaurus (tĭ răn ō sô′rŭs). A kind of flesh-eating dinosaur (p. 162)

Ultraviolet rays. Those rays in sunlight that cause the skin to become tanned. Ultraviolet rays help to make vitamin D (p. 435)

Universe. The solar system and all the stars throughout space make up the universe (p. 20)

Valve. A sort of door or hinged lid in a tube which opens and closes easily. Valves in the cylinder of an engine are places where the steam or gas enters and escapes. A faucet is a valve that may be opened and closed by turning the handle (p. 329)

Vapor. A gas. Before the liquid gasoline can be used in a gasoline engine, it must be changed into a gas, or vapor (p. 333)

Vertebrae (singular *vertebra*). The bones which form the backbone of an animal (p. 137)

Vertebrates. Animals with backbones. Horses, fish, and men are vertebrates (p. 137)

Vertical fin. A fin-shaped piece of metal on the tail of the fuselage of an airplane. The vertical fin helps to keep the airplane in a straight line (p. 426)

Vibration. A rapid back-and-forth movement. Violin strings vibrate when they are plucked. Drums vibrate when they are beaten. Sound is caused by the vibration of the air striking against our eardrums (p. 372)

Vitamin. A substance that is present in the bodies of people and other animals and in plants. There are a number of different kinds of vitamins. Vitamins help to build tissues, carry off waste, and prevent disease (p. 241)

Volt. The force with which electrons move is measured in volts (p. 344)

Warbler. A small insect-eating bird. Warblers are often seen darting among the leaves of trees in search of insects (p. 235)

Warm-blooded. Animals whose bodies remain at the same temperature all the year are said to be warm-blooded (p. 175)

Water turbine. A water wheel that is driven by the force of water striking against curved vanes or cups. These vanes or cups are placed on the rim of the wheel (p. 326)

Wedge. One of the simple machines. A knife and an ax are wedges (p. 288)

Zodiac. A belt of twelve constellations that appear in the sky during the different seasons of the year. These constellations, or groups of stars, appear to follow the sun's path through the sky (p. 449)

Index

PRINTED IN THE UNITED STATES OF AMERICA

Date Due

EDUCATION LIBRARY

EDUCATION LIBRARY
5
121570
UNIVERSITY LIBRARY
AN NEW PATHWAYS IN
Craig
Q
163
.C88N
bk.6
121570
121570
LIBRARY
OF THE
SUMMER SCHOOL
CURRICULUM
EDUCATION LIBRARY

Q 163 C88 N bk.6 c.1
Craig, Gerald Spellman, 1
New pathways in science... by
CURRHIST
0 0004 7076 450